Baltic Journal of Health and Physical Activity 2019; 11(1): 124-130
Journal of Gdansk University of Physical Education and Sport
e-ISSN 2080-9999

ORIGINAL

doi: 10.29359/BJHPA.11.1.13

The relationship between selected anthropometric variables and the sports results of early pubescent swimmers

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

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abstract

Background: Relations between anthropometric parameters and sports results in swimming are well documented, but only few studies concern young athletes. Scientific evidence do not indicate definitely, which anthropometric variables determine swimming performance among pubertal athletes.

Material and methods: Forty one swimmers at the mean age of 12.2 years (including 15 females) were examined. Body composition was assessed by Tanita BC 545N device. Body height, hand length, hand width and arm span were also determined. Anthropometric data were compared to results of 50 m freestyle and 200 m individual medley.

Results: Calculations made by Pearson's coefficient revealed significant liaisons between body height, arm span and hand length towards freestyle results. Relationships between anthropometric measurements and 200 m individual medley results were essential only in boys. The other variables showed week and insignificant correlations with sports results.

Conclusions: Results of our study suggest that in early adolescence body height and upper limb dimensions affect swimming performance much more than body composition.

Key words: swimming, anthropometrics, body composition, youth.

article details

Article statistics: **Word count:** 2,079; **Tables:** 2; **Figures:** 0; **References:** 26
Received: October 2018; **Accepted:** March 2019; **Published:** March 2019

Full-text PDF: http://www.balticsportscience.com

Indexation: Celdes, Clarivate Analytics Emerging Sources Citation Index (ESCI), CNKI Scholar (China National Knowledge Infrastructure), CNPIEC, De Gruyter - IBR (International Bibliography of Reviews of Scholarly Literature in the Humanities and Social Sciences), De Gruyter - IBZ (International Bibliography of Periodical Literature in the Humanities and Social Sciences), DOAJ, EBSCO - Central & Eastern European Academic Source, EBSCO - SPORTDiscus, EBSCO Discovery Service, Google Scholar, Index Copernicus, J-Gate, Naviga (Softweco, Primo Central (ExLibris), ProQuest - Family Health, ProQuest - Health & Medical Complete, ProQuest - Illustrata: Health Sciences, ProQuest - Nursing & Allied Health Source, Summon (Serials Solutions/ProQuest, TDOne (TDNet), Ulrich's Periodicals Directory/ulrichsweb, WorldCat (OCLC)

Funding: The study was supported by the grant no 18.610.010-300 in University of Warmia and Mazury in Olsztyn..

Conflict of interests: Authors have declared that no competing interest exists.

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INTRODUCTION

Growth indicators in young swimmers are minor before the onset of puberty, but during biological maturation anthropometric changes strongly affect swimming performance [1]. Much research has been conducted to find out how large the correlation between anthropometric indicators and the swimming performance of young swimmers is, and which of these indicators have the greatest impact on swimming performance. For example, Lätt et al. [2] discovered a significant relationship between body height and the arm span and the time in 400 m freestyle in male swimmers, whereas Morais et al. [3] found a strong correlation between arm span, height, chest circumference, hand surface area, feet surface area, trunk transverse area and the results of 100 m freestyle in boys and girls. Also, kinematics, hydrodynamics, energetics and efficiency have been investigated, but based on the results we can say that they have a minor role in swimming performance [4]. According to the literature, the stroke rate, the stroke index, arm span, body height, bone mass, spine bone mineral density, foot size, leg power and hand grip strength could be used as predictors of 100 m and 400 m front crawl performance in young swimmers [4–5]. The influence of gender on swimming performance and other variables was also investigated but no significant differences between anthropometric, kinematic and energy indicators among boys and girls were found [6]. Based on the research results, which relate to the definition of the main factors affecting young swimmers' performance, a classification of variables was created to determine the swimmer's performance from an anthropometric and biological development point of view, or in terms of increasing the level of technique and training [7].

The aim of this study was to describe the anthropometric characteristics of female and male prepubescent swimmers and to determine the contribution of chosen anthropometric factors to sports achievements.

MATERIAL AND METHODS

Forty-one children (15 girls and 26 boys) participated in the study. Girls' mean age was 12.2 ±0.5 years, whereas boys' mean age was 12.1 ±0.5 years. The training experience of the whole group was 2.4 ±0.5 years, and the average number of training sessions per week was 8.2 ±1.4 (12.3 ±2.2 training hours). Measurements were conducted in the morning, before training sessions. Participants were dressed in light clothes. Body height was assessed with a calibrated standard scale (Seca 711, Seca GmbH, Germany). Body mass, body mass index and body fat percentage were calculated with a Tanita BC 545 N device (Tanita Corp., Japan). Hand measurements were taken with a sliding calliper [8]. Hand length was assessed from the midpoint of the interstylon line to the tip of the middle finger. Hand width was measured from the radial side of the second metacarpal joint to the ulnar side of the fifth metacarpal joint [9]. Arm span was measured with a flexible steel tape from the tip of the middle finger of one hand to the tip of the middle finger of the opposite hand. During the measurement, the subject stood with his back to the wall, with both arms raised and extended to the sides. All anthropometric measurements were taken twice and repeated if 10 percent discrepancy occurred between the two measurements. Coefficient of variation (CV) was calculated for each pair of repeated measurements. The range of CV values was from 2.4 to 3.2. Readings were taken to the nearest 0.1 cm. The puberty rate was self-assessed by the participants at home, under parents' supervision, according to the Tanner

Scale [10]. Anthropometric and body composition data were compared with sports results achieved by the children during local competition in a 25-meter pool. Results of 50-m freestyle and 200-m individual medley were recorded automatically by the OMEGA timekeeping system (Omega SA, Switzerland). Sports results were expressed in FINA (International Swimming Federation) points (https://www.fina.org/content/fina-points). The authors' decision to analyse these two performances was based on the following considerations:

i. the literature provides results of correlations between anthropometry and sports results gained on distances from 25 m to 400 m. The authors' intention was to assess these correlations in a typical sprint event (50-m freestyle) and in a middle-distance event with higher technical demands (200-m individual medley);
ii. each participant was obliged to compete in both events, so that objectively measured results could be obtained from the whole group.

Participants were informed about the aim of the experiment and the parents gave their written informed consent. The experiment was conducted in accordance with the principles of the Helsinki Declaration, and the local Institutional Review Board accepted the study.

Statistical calculations were done by Statistica 13.1 (StatSoft, Tulsa, USA). The distribution of data was normal according to the Shapiro-Wilk test. Pearson's correlation coefficient (r) was utilized to evaluate the relationships between anthropometric variables and sports results. The correlation strength was interpreted in accordance with the literature [11], where 0.00–0.39 stands for a negligible and weak correlation, 0.40–0.69 is a moderate correlation and 0.70–1.00 proves a strong and very strong correlation. A paired t-test was used to assess differences between girls and boys. The level of statistical significance was established at $p < 0.05$.

RESULTS

Sports achievements, anthropometric and body composition data are presented in Table 1. According to the growth chart by Stupnicki [12], the percentage of body fat and body mass index values place the examined cohort between the 75th and 90th percentile of the population. Girls were slightly taller, and had greater arm span and body mass when compared to boys, but these differences were insignificant. Essential differences between genders were observed in the percentage of body fat and FINA scores

Table 1. Anthropometric variables and sports results of the examined swimmers (mean ±SD)

	body height [cm]	hand width [cm]	hand length [cm]	arm span [cm]	body mass [kg]	body mass index [kg/m²]	body fat [%]	maturation stage [Tanner scale]	50 m freestyle FINA points	200 m IM FINA points
GIRLS (n = 15	157.4 ±10.2	7.4 ±0.5	16.7 ±1.0	157.2 ±10.1	47.0 ±9.7	18.9 ±2.0	22.5 ±3.0*	2.1 ±0.7	279.2 ±58.3**	280.6 ±46.4**
BOYS (n = 26)	154.2 ±8.7	7.6 ±0.5	16.5 ±1.1	154.4 ±9.3	45.0 ±8.8	19.1 ±3.1	18.1 ±4.5	1.8 ±0.6	202 ±64.4	211.5 ±55.9

** $p < 0.05$ in comparison between girls vs boys*

*** $p < 0.001$ in comparison between girls vs boys*

Table 2 displays correlations between anthropometric variables and sports achievements in the studied group. In girls, significant correlations were found between body height, hand length, arm span and 50 m freestyle performance

(0.5 < r < 0.6; p < 0.05). No significant correlations were revealed between girls' anthropometric variables and their results in the 200 m individual medley. Body height was positively correlated with boys' performance both in 50 m freestyle and 200 m individual medley (0.57 < r < 0.67; p < 0.05). In boys, arm span and hand length were also associated with results in both events (0.44 < r < 0.6; p < 0.05). A negative correlation was found in boys between the percentage of body fat and sport results in both events (-0.58 < r < -0.56; p < 0.05). Maturation stage showed no correlation with sports performance in the studied cohort.

Table 2. Pearson's correlation coefficient between anthropometric variables and sports results

Anthropometric variable	GIRLS (n=15)		BOYS (n=26)	
	50 m freestyle	200 m IM	50 m freestyle	200 m IM
Body height	0.60*	0.44	0.67*	0.57*
Hand width	0.39	0.21	0.39*	0.35
Hand length	0.52*	0.50	0.51*	0.44*
Arm span	0.57*	0.43	0.60*	0.49*
Body mass	0.47	0.36	0.16	0.09
Body mass index	0.14	0.06	-0.33	-0.33
Body fat percentage	0.15	-0.00	-0.58*	-0.56*

** p < 0.05; IM – individual medley*

DISCUSSION

Correlations between anthropometric variables and swimming performance among young swimmers have been presented in previous papers. In some studies [13, 14] swimming performance was evaluated in controlled conditions, with utilization of laboratory devices (e.g. ergometer, respiratory snorkel). In both of the above-mentioned studies, positive correlations between arm span, body height and swimming performance were observed in teenage male swimmers. Nasirsade et al. [15] discovered significant correlations between body height, arm span and 200 m front crawl performance among 14-year-old male swimmers. Bond et al. [16] examined 21 boys and 29 girls at the mean age of 13.5 years in terms of anthropometric predictors of swimming performance. Anthropometric variables were correlated with the results of the 100 m freestyle. Significant correlations were found between body height, hand length and sports results in both sexes. It is worth noting that in the above-mentioned studies, just as in the current study, relationships between anthropometrics and sports results were moderate (r < 0.7). Unlike in other cited studies, the swimmers' body mass was also correlated with sports scores. The results of the present study correspond to those presented by Toskic et al. [17]. In their study, a group of 25 young swimmers was examined in terms of connections between anthropometric variables and 50 m freestyle performance. The anthropometric data is very similar to the results of the present study, and the correlations between body height (mean 156.1 cm), arm span (mean 158 cm), hand length (mean 15.9 cm) and 50 m freestyle velocity are also significant. Although body mass scores are similar in both studies, we noticed no connection between this variable and swimming performance. The results presented by Geladas et al. [18] are noteworthy. Anthropometric variables of Greek girls and boys aged on average 12.7 were correlated with 100 m freestyle performance. Significant relationships were discovered between sports results and the following variables: body height, hand length, and body mass (in boys only). No correlations between swimming performance and body

fat were found in young swimmers of both sexes. On the other hand, Dimitric et al. [19] found no relationships between body height and sprint swimming performance in 14-year-old female athletes. In their study, only arm span was correlated with the sports results of 50 m freestyle and 50 m butterfly. Body height had no effect on 25 m freestyle performance in 10-year-old girls, either [20]. When compared to our group, Greek swimmers are taller (165.5 cm in boys and 161.2 cm in girls) and heavier (54.1 kg in boys and 48.3 kg in girls). Ostrowska et al. [21] completed anthropological measurements in 11–12-year-old swimmers. The values of body height and body mass in boys were similar to our scores (155.2 cm and 43.8 kg respectively). In girls, mean body height was 155.4 cm and mean body mass 43.8 kg. Anthropometric data of 10–12-year-old swimmers presented by Greco and Denadai [22] are also similar to ours (boys' mean height 157.1 cm, body mass 46.9 kg, body fat 15.2 %; girls' mean height 155.3, mass 45 kg, body fat 22 %).

A comparison of our results to those described in available literature displays similarity in body stature among early pubescent swimmers. Moreover, our study confirms the findings from literature that anthropometric variables influence sports achievements with moderate, not strong, correlation. In our study, distinct relationships between body height, hand length, arm span and 50 m freestyle results were noted in girls and boys. Freestyle is the most common swimming event, and a substantial part of each workout is done with this technique. When a young athlete is acquainted with the freestyle technique, longer extremities would be an advantage, giving a more effective pull, slide, etc. The individual medley is much more complex in terms of technical demands. Apart from extremities dimensions, coordination abilities play an important role in that style. According to Buhl et al. [23], female swimmers achieve their peak swim speed in the 200 m individual medley at a younger age than males. In their opinion, the differences between genders in terms of individual medley results could be explained by anthropometrics characteristics, particularly by the adipose tissue content. In the current study, no correlations between body fat and sports results were revealed in girls. On the other hand, a moderate reversed correlation of these variables was found in boys. We interpret this finding by the fact that in early pubescence the distribution of body fat is different in boys and girls. At that age, boys demonstrate more waist fat that could negatively influence their desired streamlining position in the water [24–25]. We suppose that the number of examined girls may have affected the correlation coefficient results. The correlation coefficient between hand width and 50 m freestyle results had the value of 0.39 in both genders, but only in boys there was statistical significance. Moreover, a correlation between hand width and 200 m individual medley was stronger in girls, although that relationship was statistically insignificant. It is worth noting that Senel and Baykal [26] did not find relationships between length measurements (e.g. height, forearm, hand) and times of 100 m freesyle in eighteen 11–12-year-old girls, although such relevance was discovered in their 22 male peers.

Gender differences in FINA scores that we observed in the current study can be explained by the distinct classification system for female and male athletes. Girl and boys obtained almost equal mean result in the 50 m freestyle (35.95 seconds vs 35.30 seconds respectively, a non-significant difference), but the difference in the obtained FINA points was essential. A similar situation occurred in the case of the 200 m individual medley.

In our opinion, anthropometric measurements should be taken regularly in prepubertal children in order to find appropriate individuals for competitive swimming. These measurements should also be conducted among children already involved in swimming, because anthropometric characteristics can explain some aspects of individual sports development.

CONCLUSIONS

In the light of the presented data, body height, arm span and hand length have the greatest impact on freestyle sprint performance in pubescent athletes.

In the case of longer distances, these relationships are not so obvious, especially in girls.

Gender differences in body fat contribution may affect swimming results in early adolescence.

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Cite this article as:

Bielec G, Jurak D.
The relationship between selected anthropometric variables and the sports results of early pubescent swimmers.
Balt J Health Phys Act. 2019;11(1):124-130.
doi: 10.29359/BJHPA.11.1.13