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Athletes' anthropometrical measurements and physical capacity influence on learning competitive swimming techniques

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The aim of our study was to look at the relationship of the anthropometrics and exercise capacity to the ability to acquire swimming skills in freestyle (front crawl), backstroke, and breaststroke.

Research methods and organization. Eighteen 17–18 aged male athletes from various (not directly related with swimming) sports volunteered to participate in the study, namely, standard swimming learning program, which consisted of 40 sessions from 60 to 70 minutes in duration with the frequency of three times per week. Anthropometrical measurements, exercise capacity tests (Eurofit tests), and analysis of swimming abilities were all performed before the initiation of the swimming learning program, and the swimming abilities were re-tested after the successful completion of the learning process.

Results. The results of the study showed the majority of young male athletes engaged in "terrestrial" sports being well physically developed to be poor swimmers. Nevertheless, they are able to successfully acquire skills of competitive swimming strokes during the well-organized learning process of 40 learning sessions. The degree of the improvement in all the strokes taught is related to body height, skinfold thickness, as well as circumferences of body segments, the former correlating to the post-program swimming abilities positively, and the latter negatively.

Conclusion. Consequently, taller, fatter (and thus more buoyant) young individuals with smaller body-segment girths seem to favour from their somatotype in the process of learning to swim freestyle, backstroke, and breaststroke.

Key words: swimming, motor-learning, anthropometrics

INTRODUCTION

Swimming is not only an athletic endeavour but also a life saving necessity. Everyone should be able to swimming because 71 percent of the entire earth's surface is covered with water, dry land consisting of only 29 percent. (1)

It has been estimated that nearly half a million people drown in the world every year. 97 percent of drowning deaths have taken place in the undeveloped countries. Men drown more often than women, boys more frequently than girls. In the United States, males account for 80 percent of drowning victims (2). In the United States, drowning deaths are the third most common cause among all accidental deaths (3, 4). Main injury causes of death in China, in descending order, are: suicide, traffic accident, drowning, falling, poisoning, homicide, burn and scald, and iatrogenic injury (5). In some regions of Canada, drowning fatalities surpass road accident deaths. 50 to 78 percent of adults drown in open water, and 56 percent of children drown in artificial facilities (swimming pools, baths etc.) (2). In Holland, there are approximately 300 drowning deaths every year (6), and 217 drowning fatalities occur each year on average in Lithuania (7). As research has shown many people overvalue their swimming abilities, while one of the main reasons of drowning is incompetence in swimming. Other causes are careless activities near open water, including the use of alcohol; children left unsupervised; acute health problems such as cardiac arrhythmias, heart attacks etc. (7).

Human being is born with the skill to walk and to swim, but after a few months swimming skill disappears. Everyone is able to learn swimming: the handicapped, pregnant women, babies etc. The most suitable years for learning to swim are ages 8–10 (8–12), but older people can also learn (10). Infants are taught swimming as well (13). However, mostly children are taught swimming in Lithuania, whereas little effort is being made to educate swimming in adults. There is a considerable body of literature regarding teaching swimming children where preparatory water exercises for teaching swimming are analysed, guidelines for proper training are given, detection and prevention of errors are discussed, and recommendations on how to learn one or more competitive swimming strokes are given (8, 11, 12). A famous former swimmer from the United States Jane Katz (9), writing in her book on teaching swimming

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indicates that most of the emphasis in learning to swim should be placed on breathing correctly. Russian authors have continuously emphasized the need of specific exercises that help feel comfortable in water (14). Krasauskienė and Statkevičienė (15) have shown that observation of swimming lessons has a significant positive impact on children's success in learning to swim: it appeared that the children, who watch others' swimming practices, learn swimming technique quicker than those who do not.

Once the swimming skill is acquired, it remains for a lifetime. Swimming is a good activity for a healthy lifestyle and is a good recreational activity. If a person knows how to swim, he / she can save someone else's life as well as his own. Therefore, everyone should take swimming lessons and learn to swim.

There are only scarce data on the anthropometrical and exercise capacity parameters as possible predictors of swimming abilities, and no data at all could be found whether these parameters can serve as predictors of the abilities to learn swimming quicker and/or better.

Objectives of the study were as follows: (a) to evaluate the ability athletes (various sports) to swim, as well as their somatic development and level of physical condition (some of the exercise capacity characteristics) before the beginning of learning to swim; (b) to determine the changes in swimming technique due to 40 swimming lessons; (c) to establish the possible relationship of somatic development and physical condition to learning abilities to swim backstroke, breaststroke, and crawl.

METHODS

1. Anthropometry (16). 2. Testing (Eurofit tests). 3. Subjective evaluation of swimming technique (17).

Participants of the study were 17–18 year old athletes from various sports (n = 18): track and field, basketball, volleyball, wrestling, and bodybuilding. They were offered to participate in an experiment and volunteered to participate in the swimming-learning program. Swimming lessons were held three times a week; each lasted from 60 to 70 minutes. During the first session, the subjects were measured for their height, body mass, chest girth, waist and extremities' circumferences, skinfold fat content (subscapular, triceps, abdominal, thigh and shin skinfold thicknesses), as well as feet, hand, and shoulder width. Participants performed Eurofit tests to determine their exercise capacity, namely, maximum number of pull-ups, number of sit-ups in 30 seconds, left and right hand grip isometric strength, and both feet jump distance from standing position. In addition, the subjects were tested for their ability to swim, i. e. they were asked to show how far they could swim without stopping. The distance was recorded, and technique errors were noted. The data obtained were compared with those of the swimmers' (18) and with those of non-athletic males of comparable age (19).

Participating athletes were taught preparatory water exercises, and then back stroke, breaststroke and crawl techniques. Having learned the initial water exercises, the subjects were asked to glide on the water surface, pushing off from the pool wall on their back, and then on the stomach. In both cases, the volunteers executed the glide with their arms held forward, legs close together, and with the face in the water. The participants took a deep breath, maximally pushed off from the wall, and glided as far as they were able. In that position they continued either until they ran out of breath or came to a complete stop. The distance was measured from the pool wall to the participant's heels with a ruler.

After completion of the preparatory exercises, the participants were taught competitive back stroke, breast stroke and crawl techniques. At the end of the learning program, each subject swam 50 meters in each of the above-mentioned competitive strokes. The swimming technique was rated on a 10 point system (17), according to which, the 10 point score was assigned to the participant who demonstrated a professional swimmer's technique, and one point was given to a participant who made numerous highly visible errors, or when the participant only managed to cover a distance of up to 10 meters.

Statistics

Average and standard deviation (shown in the parentheses after the average) were calculated; Students t-test and Pearson correlation analysis were performed, with the criteria of significance chosen as an alpha error of 0.05.

RESULTS

Somatic development and exercise capacity of the studied athletes

The total body measurements are given in Table 1. The height and chest girth of our athletes hardly differed from the non-athletic Lithuanian youths ($p > 0.05$), but the body mass was

Table 1. **Total body measurements in our athletes, the best Lithuanian swimmers of various strokes (Statkevičienė, 2002), and non-athletic 18 year old individuals (Tutkuvienė, 1995)**

	Height (cm)	Weight (kg)	Chest circumference (cm)
Our researched athletes (n = 18)	181.8 (8.8)*	76.4 (7.3)*	93.0 (4.5)**
Non-athletes	179.6 (5.4)	69.9 (8.6)	91.9 (5.8)
Freestyle swimmers	191.8 (11.0)	82.0 (13.0)	100.2 (7.7)
Backstroke swimmers	193.0 (2.3)	86.0 (4.9)	100.0 (0.7)
Butterfly swimmers	180.0 (5.7)	70.0 (0.7)	97.8 (1.8)
Breaststroke swimmers	**183.3 (4.0)**	**73.0 (5.6)**	101.2 (6.3)

Note. * significantly different from freestyle and backstroke swimmers ($p < 0.05$); ** significantly different from freestyle, backstroke, and breaststroke swimmers ($p < 0.05$).

Table 2. **Body segment sizes (cm) of our athletes and the best Lithuanian swimmers (Statkevičienė, 2004)**

Segment	Our athletes	Swimmers	p
Trunk	78.2 (5.2)	79.8 (2.6)	> 0.05
Upper arm (right)	32.3 (3.5)	31.5 (2.9)	> 0.05
Forearm (right)	28.3 (2.2)	28.3 (1.7)	> 0.05
Hip (right)	55.9 (4.0)	53.6 (2.4)	> 0.05
Calf (right)	38.4 (1.8)	37.8 (2.1)	> 0.05

Note. Standard deviations are given in parentheses.

Table 3. **Skinfold thickness (mm) of our subjects, the best Lithuanian swimmers of various strokes, and of the non-athletic Lithuanian youths (Tutkuvienė, 1995)**

Skin fold	Our athletes (n = 18)	Non-athletes	Swimmers (n = 15)
Subscapular	9.5 (1.4)	9.5 (3.1)	7.3–11.0 (1.2–4.2)
Triceps	5.3 (2.3)		4.3–7.0 (0.5–2.5)
Abdominal	10.4 (3.4)	12.5 (6.6)	7.6–12.0 (0.3–3.5)
Thigh	11.7 (2.9)	12.6 (4.6)	8.5–15.0 (1.8–6)
Shin	10.0 (3.7)		8.5–12.3 (0.6–4.9)

Note. Standard deviations are given in parentheses.

Table 4. **Exercise capacity indices of our athletes**

Index	
Trunk strength (number of sit-ups in 30 seconds)	29.36 (0.74)
Strength stamina (maximum number of chin pull-ups)	9.29 (0.55)
Explosive strength (jump distance from standing position (m)	2.33 (0.09)
Isometric strength (isometric left hand grip) (kg)	55.9 (7.7)
Isometric strength (isometric right hand grip) (kg)	56.3 (3.1)

Note. Standard deviations are given in parentheses.

Table 5. **Swim styles that could be performed and distances that could be achieved by our subjects during the initial practice session, as well as the technical mistakes**

Distance	0 m	Up to 10 m	11–19 m	20–25 m
Number of subjects	11	4	2	1
Swimming style	–	Crawl (head above the water)	Crawl (head above the water)	Crawl + backstroke
Evaluation of swimming technique (points)	0	1	2	2
Abilities	Everybody could plunge under the water and stay there for 5–10 s			
Errors in swimming technique		Bad body position. Head above the water, breathing above the water, legs deep under the water, bad arm pull, scissors leg motions		

greater ($p < 0.05$) in the non-athletes. Body segment sizes are compared in Table 2.

In Table 3, the skinfold fat content indices of our studied athletes are presented. Skinfold thickness was very similar to that of swimmers.

In general, our athletes did not differ from non-athletic youths of the same age relative to their height and chest dimensions as well as their skinfold fat content, but were shorter than backstroke and free style swimmers.

Exercise capacity indices of our athletes are presented in Table 4.

Swimming ability

Table 5 summarizes swimming styles our subjects were able to use, and distances the athletes covered during the first practice session, as well as technical errors they committed.

The results presented in Table 5 show that most of our athletes were unable to swim. There were 11 athletes who managed to cover 10 meter water distance, but four of them did not swim correctly, two reached 11–19 meter distance, but only one swam 25 meters (however, after 12 meters he switched to back stroke due to his inability to breathe correctly). Swimming technique was given very low score, the average being 0.5 out of the possible 10. This indicates that our subjects were either completely ignorant of swimming or swam poorly.

As regards the swimming technique errors, we can state that all of our athletes committed at least one of the following errors:

1. Inhaling with the head raised above water surface.
2. Wrong body positioning, the angle of attack being 30 degrees.
3. Incorrect arm movements, too short strokes.
4. "Scissors'" kick.

However, all the athletes were able to immerse themselves under water and remain submerged for 5 to 10 seconds. Underwater submersion is a very important element in learning to swim, and it usually takes a considerable amount of time to achieve. It also requires courage and self-confidence. The ability to submerge with open eyes substantially advanced the learning process (9, 11, 12, 14, 20).

In summary, we can state that up to the time of learning the swimming process our subjects either did not know how to swim, or swam poorly. A positive aspect was that they all could submerge and open their eyes under water.

Planning teaching the athletes under research to swim

The plan of practices and teaching is presented in Table 6. The program began with two lessons of preparatory exercises, which were sufficient to teach the subjects to glide on the water surface in supine and prone positions without any floatation devices. It is agreed that when a person learns to glide supine and prone with body straight and the face submerged, it is then possible to teach swimming techniques effectively. Leg movements in crawl and backstroke are simple, and learning them did not consume much time. These movements are similar to walking locomotion, and thus subjects were taught them in the water just in five lessons. Most of the time of the teaching program was devoted to teaching the breaststroke kick, because this motion is substantially different from other swimming strokes and is not customary to humans. The feet must be turned sideways, and it is rather difficult to perform the movement symmetrically and to time it correctly (10, 20, 21). These and similar motions must first be learned on land (22, 23). Swimming teaching exercises are always done on land at first when the subject is learning a new swimming stroke. Learning motions on land makes it easier to acquire the needed skills in water (9, 21).

The data presented in Table 7 are on gliding after push off from the wall. The obtained data show that our athletes achieved a similar distance when gliding supine or prone ($p > 0.05$).

Table 7. **The subjects' prone float data (m)**

Distance of prone float	
Prone float (on the breast)	6.9 (2.1)
Prone float (on the back)	7.3 (1.9)

Note. Standard deviations are given in parentheses.

Swimming technique after swimming program

From the data presented in Table 8 we can see that after the swimming program the athletes obtained a good technique in front crawl, backstroke, and breaststroke. Most effort was given to teaching the backstroke, since the acquisition of this technique is slower than that of the other strokes. It would be useful to perform additional research to determine if the backstroke is more difficult for athletes to learn as compared with other strokes.

Table 8. **The athletes' swimming technique after swimming learning period**

Backstroke	Breaststroke	Crawl (Freestyle)
7.7 (1.2)	8.4 (1.65)	8.2 (1.6)

Note. Standard deviations are given in parentheses.

Correlation analysis on physical development (anthropometrical indices) and exercise capacity

Table 9 presents total body measurement and swimming technique evaluation correlation coefficients. The data obtained indicate that height correlated significantly with all the swim-

Table 6. **Swimming lessons plan for teaching the athletes to swim**

	Lessons															
	1–2	3–4	5–7	8–10	11–16	17	18	20–23	24	25	26–29	30–32	33–35	36	37	38–40
Land exercises	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Preparatory exercises in water	+	+														
Backstroke leg movements		+	+													
Freestyle leg movements		+	+													
Breaststroke arm movements			+	+	+											
Backstroke arm movements				+												
Breaststroke leg movements					+	+	+									
Freestyle arm movements														+	+	+
Backstroke arms and legs coordination						+	+	+	+	+	+					
Breaststroke arms and legs coordination								+			+	+	+			
Freestyle arms and legs coordination														+	+	+
Perfection of swimming styles technique														+	+	+

Table 9. **Correlation coefficients between total body size and swimming technique**

Stroke	Body height	Body weight	Chest circumference
Backstroke	**0.70** ($p < 0.01$)	–0.03 ($p > 0.05$)	0.27 ($p > 0.05$)
Breaststroke	**0.68** ($p < 0.01$)	–0.41 ($p > 0.05$)	0.26 ($p > 0.05$)
Freestyle	**0.45** ($p < 0.05$)	–0.29 ($p > 0.05$)	**0.47** ($p < 0.05$)

Note. Significant coefficients are in bold.

Table 10. **Correlation coefficients between circumferences and swimming technique**

Circumferences (girths)	Backstroke	Breaststroke	Freestyle
Trunk	–0.03 ($p > 0.05$)	–0.39 ($p > 0.05$)	–0.35 ($p > 0.05$)
Upper arm (right)	–0.43 ($p < 0.05$)	–0.35 ($p > 0.05$)	–0.41 ($p > 0.05$)
Forearm (right)	–0.52 ($p < 0.05$)	–0.38 ($p > 0.05$)	–0.39 ($p > 0.05$)
Thigh (right)	–0.41 ($p < 0.05$)	–0.28 ($p > 0.05$)	–0.41 ($p > 0.05$)
Calf (right)	–0.36 ($p > 0.05$)	0.13 ($p > 0.05$)	–0.39 ($p > 0.05$)

Note. Any of the coefficients of statistical significance.

Table 11. **Correlation coefficients between athletes' skinfold thicknesses and swimming technique**

Skinfold	Subscapular	Triceps	Abdominal	Thigh	Shin
Backstroke	0.65 ($p < 0.05$)	0.52 ($p < 0.05$)	0.63 ($p < 0.05$)	0.38 ($p > 0.05$)	0.44 ($p < 0.05$)
Breaststroke	0.39 ($p > 0.05$)	0.41 ($p > 0.05$)	0.60 ($p < 0.05$)	0.52 ($p < 0.05$)	0.45 ($p < 0.05$)
Freestyle	0.52 ($p < 0.05$)	0.58 ($p < 0.05$)	0.29 ($p > 0.05$)	0.63 ($p < 0.05$)	0.52 ($p < 0.05$)

ming stroke techniques. It means that taller athletes absorb crawl, backstroke and breast stroke techniques more readily.

The data presented in Tables 10 and 11 reveal significant athletes' body dimension and skinfold thickness correlation with swimming stroke technique evaluation indices. Subjects with large body segment dimensions seemed to have disadvantages to master swimming skills. However, all skinfold thickness correlated positively with all the swimming stroke technique. Visible tendency shows that larger skinfold fat is not a negative aspect for evaluating swimming stroke techniques.

DISCUSSION

Our results have shown that anthropometrical parameters and exercise capacity have influence on the ability of the young athletes to acquire swimming skills. Namely, taller subjects having more subcutaneous fatty tissue learn swimming technique more successfully than shorter and leaner athletes.

Bulgakova (23) demonstrated that tall swimmers have better results in back stroke and free style than shorter swimmers. Lithuanian top backstroke and free style swimmers are very tall; therefore, it is not surprising that our volunteers were shorter than the swimmers. We could not compare our obtained data with the data of the non-athletic youths because such data does not exist, except for head dimensions – it was 57.5 (1.8) cm in our athletes, whereas it is 57.6 (2.1) cm in the non-athletes. Lithuanian non-athletic 18-year-old males' right and left handgrip strength (50.7 ± 7.2 and 47.9 ± 7.9 kg, respectively) (Tutkuvienė, 1995) is smaller than those of our studied athletes (Table 4).

Our data have shown that taller people may have the ability to swim better and more correctly. In other words, taller athletes learn to swim correctly quicker than short athletes. The negative correlation of body mass with back stroke, crawl and breast stroke technique score shows that large body mass is not a desirable attribute in learning to swim. However, the athletes who have a larger subcutaneous fat content also seem to have a higher probability to learn to swim correctly.

Negative body mass correlation with swimming technique and the tendency of significance in positive correlation with subcutaneous fat content lead us to think that larger skinfold thickness is not detrimental to youths in obtaining swimming skills. Skinfold fat makes the body more buoyant in the water. As expected, the fat was distributed evenly over the entire body, and that is typical of male. The body buoyancy depends on the body mass components and their density. Body mass components' density varies substantially. Bone tissue has a density of 1.7–1.9 g/cm^3, muscle tissue 1.04–1.05 g/cm^3, and fat 0.92–0.94 g/cm^3. On average, the whole body density after deep inhalation is 0.95–0.99 g/cm^3; and after exhalation it is 1.02–1.06 g/cm^3 (24). However, the ability to maintain body on the surface of the water is dependent not only on body composition, but also on body shape, as well as body position in the water.

The negative correlation between swimming technique score and the dimensions of body segments may mean that the large body parts hinder the development of swimming technique. With the increasing body dimensions, the water resistance while swimming also increases. People with large body dimensions have less joint flexibility, which is inevitable in striving to reach top competitive results (23). However, the positive correlation between swimming technique and skinfold thickness, but negative relationship between swimming technique and body segment dimensions lead us to think that athletes having large body dimensions due to large muscle mass and dense bones will have difficulties in acquiring proper swimming technique.

CONCLUSIONS

Learning to swim by 17–18 year old youths and the evaluation of their swimming technique is impacted by their anthropometrical indices: height, body mass, body parts' dimensions and the skinfold fat content. The greater probability is that tall persons having relatively small body mass and relatively small extremity dimensions but larger skinfold content will learn to swim faster and with higher grades than persons with different body dimensions.

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SPORTININKŲ ANTROPOMETRINIŲ IR FIZINIO PAJĖGUMO RODIKLIŲ RYŠYS SU GEBĖJIMU TAISYKLINGAI PLAUKTI

Santrauka

Tyrimo tikslas – nustatyti kai kurių antropometrinių ir fizinio pajėgumo rodiklių sąsają su gebėjimu įsisavinti plaukimo nugara, krūtine ir laisvu stiliumi (krauliu) techniką.

Tyrimo metodai ir organizavimas. Tyrime (mokymo plaukti programoje) dalyvavo 17–18 metų įvairias (tačiau ne vandens) sporto šakas kultivuojantys jaunuoliai (n = 18). Plaukimo pamokos (iš viso 40 pamokų) vyko tris kartus per savaitę po 60–70 minučių. Antropometriniai matavimai, taip pat fizinio pajėgumo bei mokėjimo plaukti tyrimai buvo atlikti prieš mokymo programos pradžią; po jos buvo įvertinta sportininkų plaukimo trimis skirtingais sportinio plaukimo būdais technika. Mūsų plaukti mokomi sportininkai iš esmės nesiskyrė nuo nesportuojančių to paties amžiaus jaunuolių ne tik kūno matmenimis, bet ir poodinio riebalinio audinio kiekiu, tačiau buvo žemesni už nugara ir laisvuoju stiliumi plaukiančius plaukikus. Nors ir nemokėdami plaukti, mūsų tirti sportininkai buvo geros funkcinės būklės.

Tyrimo rezultatai rodo, kad dauguma ne vandens sporto šakas kultivuojančių jaunuolių, nors fiziškai yra gerai išsivystę, taisyklingai plaukti nemoka, tačiau po 40 pamokų jų plaukimo technika ženkliai pagerėja.

Išvada. Įsisavinant plaukimo techniką skirtingą įtaką turi jaunuolių ūgis, kūno dalių apimtys bei odos raukšlių storis: didesnė tikimybė, kad aukšti, turintys nedideles galūnių segmentų apimtis, bet storesnes odos klostes jauni sportininkai nugara, krūtine ir laisvu stiliumi (krauliu) taisyklingai plaukti išmoks greičiau.

Raktažodžiai: plaukimas, judesių mokymas, antropometrija