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Investigation of the Relationship Between Selected Body Compositions and Short and Medium Distance Swimming Performances

Seçilmiş Vücut Kompozisyonlarının Kısa ve Orta Mesafe Yüzme Performansları İle İlişkisinin Araştırılması

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Abstract

This study aimed to investigate the relationship between age, height, body weight, shoulder width, hand, foot, leg and stroke length and 50 m, 100 m and 200 m freestyle and backstroke swimming performances. The body composition measurements of 24 male individuals who received swimming training and whose average sports age was 2.30 ± .57 years were taken. At the same time, their 50 m, 100 m and 200 m freestyle and backstroke swimming times were determined. The analysis of the obtained data was performed using descriptive and correlation tests in the SPSS 27 package program. The study findings revealed that 50 m freestyle swimming performance and body compositions showed a negative significance ($p<0.05$). It was determined that 100 m freestyle swimming performance had a negative, significant ($p<0.05$) relationship with all other studied parameters except the age variable. Again, it was determined that the negative relationship between 200 m freestyle swimming performance and body compositions was significant ($p<0.05$). It was observed that there was a significant ($p<0.05$) relationship between 50 m backstroke swimming performance and height, shoulder width, hand, foot and leg length. It was revealed that there was a significant relationship between 100 m and 200 m backstroke swimming performance and height, body weight, stroke, hand, foot and leg length at $p<0.05$ level. As a result, it was revealed that almost all of the studied body compositions positively affected the performance in different swimming styles, and only these effect levels differed in terms of significance. In this context, it is thought that body compositions can be used as indicators in swimmer selection.

Keywords Swimming performance, Body composition, Relationship.

Öz

Bu çalışmayla, yaş, boy uzunluğu, vücut ağırlığı, omuz genişliği, el, ayak, bacak ve kulaç uzunluğu ile 50 m, 100 m ve 200 m serbest ve sırt üstü yüzme performansları arasındaki ilişkisinin araştırılması amaçlandı. Yüzme eğitimi alan, spor yaşları ortalaması 2,30 ± ,57 yıl olan 24 erkek bireyin söz konusu vücut kompozisyon ölçümleri alındı. Aynı zamanda bunların 50 m, 100 m ve 200 m serbest ve sırt üstü yüzme süreleri belirlendi. Elde edilen verilerin analizleri SPSS 27 paket programında descriptive ve korelasyon testleri kullanılarak yapıldı. Çalışma bulguları, 50 m serbest yüzme performansı ile vücut kompozisyonlarının negatif yönde anlamlılık ($p<0,05$) gösterdiğini ortaya koydu. 100 m serbest yüzme performansının yaş değişkeni dışındaki diğer çalışılan tüm parametrelerle negatif yönlü, anlamlı ($p<0,05$) ilişki içerisinde olduğu belirlendi. Yine 200 m serbest yüzme performansının da vücut kompozisyonları ile arasındaki negatif ilişkinin anlamlı ($p< 0,05$) olduğu saptandı. 50 m sırtüstü yüzme performansı ile boy uzunluğu, omuz genişliği, el, ayak ve bacak uzunluğu ile anlamlı ($p<0,05$) ilişki içerisinde olduğu görüldü. 100 m ve 200 m sırtüstü yüzme performanslarının boy uzunluğu, vücut ağırlığı, kulaç, el, ayak ve bacak uzunluğu ile $p<0,05$ düzeyinde anlamlı ilişki içerisinde olduğu ortaya çıktı. Sonuç olarak, çalışılan vücut kompozisyonlarının neredeyse tamamının farklı yüzme stillerdeki performansı pozitif yöne etkilediği, sadece bu etki düzeylerinin anlamlılık bakımından farklılık gösterdiği ortaya çıktı. Bu bağlamda yüzücü seçiminde vücut kompozisyonlarının birer belirteç olarak kullanılabileceği düşünülmektedir.

Anahtar Kelimeler Yüzme performansı, Vücut kompozisyonu, İlişki

Introduction

Nowadays, Swimming is a sport practiced by millions of people for both performance and health. Its prevalence is increasing day by day in the world and in our country. There are many factors that affect swimming performance in athletes. Some of these can be listed as skill, motivation, motor and anatomical characteristics, as well as equipment. In fact, swimming has been defined as an individual, cyclical, continuous, closed and mixed activity depending on genetic, contextual, psychological (Fernandes et al., 2008), biomechanical, energetic, hydrodynamic (Morais et al., 2012) and anthropometric factors (Jürimäe et al., 2007). It is thought that anthropometric characteristics, like all other parameters, can make a difference in performance in high-level athletes. Determining that this is the case will make positive contributions to the selection of athletes and training plans of swimming instructors and coaches.

Swimming is different from other sports activities due to the nature of the environment in which it is performed; this requires specific temporal-spatial and energetic adaptations (Marinho et al., 2007). Since they are in constant interaction with water, swimmers seek the production of propulsive forces that maintain or increase their swimming speed (Kwon and Casebolt, 2006). Swimming performance depends on the ability to generate propulsive forces and minimize hydrodynamic drag that opposes displacement (Berger et al., 1997; Martínez et al., 2011). This can be stimulated by improving biomechanical patterns (Vantorre et al., 2014) and swimming technique (Scorțenschi, 2019). In addition, performance can be affected by variability in body composition (Charmas and Gromisz, 2019) and anthropometric characteristics (i.e. weight, body mass index, height and wingspan) (Morais et al., 2012; Zuniga et al., 2011). The selection of swimmers is based on test results, not on the subjective opinions of coaches. These results depend on psychological, morphological, physiological and technical factors based on individual genetics and training. Although it is well known that these factors affect physical performance (Aspenes and Karlsen, 2012), the extent to which they affect the performance of adolescent swimmers is still unclear. Previous studies focusing on identifying variables affecting performance in swimmers aged 11 to 14 years have stated that anthropometric variables (especially in males) and specific fitness (aerobic speed and endurance) and technical areas (especially in females) determine performance in short-distance swimming events (Saavedra et al., 2010).

This study was conducted to determine whether there is a relationship between selected body compositions and short- and medium-distance freestyle and backstroke swimming performances.

Material and Methods

Research Model

This study used a descriptive and relational research method. The study was conducted on 24 male individuals with an average age of 10.33±.76 years, who had been receiving swimming training for an average of 2.30±.57 years. The participants' height, stroke, hand, foot and leg lengths, body weights and shoulder widths were measured. On the other hand, the participants' 50 m, 100 m and 200 m freestyle and backstroke swimming times were determined. All measurements were taken while the participants were in swimsuits.

Measurement methods

Height: The participants were measured in centimeters (cm) with a meter fixed to the wall in anatomical posture position without shoes.

Body weight: The individuals' weights in kilograms were measured using a sensitive electronic scale while they were barefoot and in swimsuits.
Hand length: The distance between the distal of the styloid process of the radius and the tip of the 3rd finger on a straight line between the forearm and hand. The distance between the distal of the styloid process of the radius and the tip of the 3rd finger was measured. The position is the same as the arm and forearm. The measurement was made from the dorsal side of the hand while the fingers were slightly abducted and fully extended.

Foot length: The participants were asked to place their feet on a flat surface with the heels facing the wall. They were warned to maintain their natural position without stretching or bending their feet too much. Again, it was said that the toes should be straight and not loose. In this position, the fingertips were drawn with a pencil. Then this distance was measured and recorded.

Leg length: The leg length measurements of the participants included in the study were made with a tape measure while they were in anatomical posture. The starting point was the spina iliaca anterior superior or umbilicus (Solomon, 1999), and the ending point was the medial malleolus (Öztürk et al., 1997).
Foot length: The distance between the tips of the 3rd fingers of both hands while the back is leaning against the wall, the arms are at the sides and parallel to the ground, and the dorsal side of the hand is in contact with the wall. Stroke length was determined by measuring the distance between the tips of the middle fingers of both hands with a tape measure while the arms were extended to the sides with the back against the wall.
Shoulder width: Shoulder width is defined as the distance between the acromion points (Lohman, 1988). The distance between the two acromions was measured while the upper body of the person was bare and standing, with the arms hanging comfortably to the side of the body.

Swimming performances: The measurement of the swimming style performances of the participants included in the study was made in a competition environment created in a 25-meter swimming pool. During the measurements, motivational feedback was given to all athletes so that they could show maximum effort. An electronic scoreboard was used to determine swimming times.

Results

Table 1: Average values of body composition of participants

Variable	n	Mean	Standard Deviation
Age (years)	24	10,33	,76
Height (cm)	24	147,92	9,78
Body weight (kg)	24	40,49	8,65
Shoulder width (cm)	24	52,17	15,93
Earmuff length (cm)	24	144,29	13,23
Hand length (cm)	24	16,25	2,07
Foot length (cm)	24	22,08	2,00
Leg length (cm)	24	84,67	8,63

Table 2: Relationship between selected body compositions of participants and swimming performances (n=24)

Variable		50 m freestyle swim time	100 m freestyle swim time	200 m freestyle swim time	50 m backstroke swim time	100 m backstroke swim time	200 m backstroke swim time
Age (years)	Correlation	-,421*	-,152	-,423*	-,273	-,385	-,272
	p	,040	,479	,039	,197	,064	,199
Height (cm)	Correlation	-,727**	-,659**	-,743**	-,515**	-,556**	-,492*
	p	,000	,000	,000	,010	,005	,015
Body weight (kg)	Correlation	-,625**	-,574**	-,741**	-,378	-,432*	-,420*
	p	,001	,003	,000	,068	,035	,041
Shoulder width (cm)	Correlation	-,808**	-,791**	-,817**	-,656**	-,386	-,370
	p	,000	,000	,000	,001	,062	,075
Earmuff length (cm)	Correlation	-,647**	-,498*	-,561**	-,323	-,626**	-,577**
	p	,001	,013	,004	,124	,001	,003
Hand length (cm)	Correlation	-,731**	-,628**	-,650**	-,410*	-,537**	-,516**
	p	,000	,001	,001	,046	,007	,010
Foot length (cm)	Correlation	-,774**	731**	-,841**	-,561**	-,452*	-,426*
	p	,000	,000	,000	,004	,027	,038
Leg length (cm)	Correlation	-,735**	-,633**	-,764**	-,490*	-,606**	-,512*
	p	,000	,001	,000	,015	,002	,011

*p<0,05; ** p<0,01

When Table 2 was examined, it was seen that there was a negative and significant ($p<0.05$) relationship between the age variable of the participants and the 50 m and 200 m freestyle swimming time. It was determined that there was a significant ($p<0.05$) and negative relationship between the height value and all swimming performances included in the study. It was determined that the relationship between the body weight variable and the swimming style performances in question was negative and significant ($p<0.05$). It was seen that there was a negative and significant ($p<0.01$) relationship between the shoulder width values of the participants and all freestyle and 50 m backstroke swimming performances included in the study. When the stroke length values were examined, it was found that there was a negative and significant ($p<0.05$) relationship with all swimming performances except the 50 m backstroke swimming performance. When the relationship between the hand length values of the participants and their swimming performances was taken into consideration, it was determined that there was a negative and significant ($p<0.05$) relationship with all swimming performances. Likewise, it was revealed that foot and leg length values had a negative and significant ($p<0.05$) relationship with performance in all swimming styles

Discussion and conclusion

When the age variable and swimming performances of the participants included in the study were taken into consideration, it was revealed that there was a negative ($r= -.421$) and significant ($p< 0.05$) relationship with 50 m freestyle swimming time and a negative ($r= -.423$) and significant ($p< 0.05$) relationship with 200 m freestyle swimming. Although the relationship with other swimming performances was negative, it was not significant ($p> 0.05$). In the study conducted by Bongard et al. (2007) in which they evaluated the one-hour swimming performance of 4,271 healthy men and women between the ages of 19–91, they revealed that there was a decrease in performance as age increased. Again, Donato et al. (2016) followed the swimming performances of 321 women and 319 men who participated in the US Masters Swimming Championship for 12 years. As a result, they reported that performance decreased with age. This decrease with age has been attributed to the collective decreases in cardiovascular, respiratory, metabolic and neuromuscular functions (Dempsey and Seals, 1995). Despite these decreases, it is thought that the increase in body weight that occurs with age may also be effective. In the study conducted, contrary to the literature, it is thought that the increase

in swimming performance with increasing age may be related to the age groups studied. The average age of the groups in the studies mentioned above is quite high. After middle age, bone mineral density and muscle mass decrease in women and men, while body fat ratio increases. This has an inevitable negative effect on performance. The study group is in the developmental period. The increase in bone strength and muscle strength is a general characteristic of this period. This period is also one of the periods when body fat percentage is at its lowest. This may seem natural when the load-force relationship in individuals is taken into consideration.

It is a matter of curiosity how height affects swimming performance in swimmers and whether this can be accepted as a criterion. In the study conducted, height was found to be associated with 50 m freestyle swimming time and r= -.727; A negative and significant correlation was determined at the level of $p<0.01$ with 100 m freestyle swimming time r= -.659; $p<0.01$ with 200 m freestyle swimming time r= -.743; $p<0.01$ with 50 m backstroke swimming time r= -.515; $p<0.01$ with 100 m backstroke swimming time r= -.556; $p<0.01$ and with 200 m backstroke swimming time r= -.492; $p<0.05$. Khosla (1984) reported that the finalists in women's swimming at the 1976 Montreal Olympic Games were approximately 3.5 cm taller than the non-finalists. Chengalur and Brown (1992) reported a strong correlation between the body height of the competitors in the 200 m swimming events at the 1988 Seoul Olympic Games and the final times they achieved. In another study conducted to reveal the role of height on 50 m freestyle swimming performance (Hlavaty, 2010), it was determined that there was a relationship between body height and performance. Zampagni et al., (2008) evaluated the role of height on swimming performances in different swimming distances of 50, 100, 200, 400 and 800 m freestyle in a competition attended by elite master swimmers and suggested that body height is one of the three best determinants in short distance events. In the study conducted by Charles and Bejan (2009) on the speed in men's 100 m freestyle records, it was revealed that height has an effect on speed. It is thought that this situation may be due to the stroke and leg length provided by height. In fact, Cochrane et al. (2015) reported in their study that one of the variables that significantly contributes to the prediction of propulsive force is the body height of the swimmers. On the other hand, Bouchard et al. (1976) reported in a study with 237 boys between the ages of 8 and 18 that body mass and height positively affected the submaximal work capacity of swimmers.

In terms of the relationship between body weight values and swimming performance, it was determined that there was a negative relationship between the body weight values and swimming performances of the participants in the study. However, it was revealed that the 50 m backstroke swimming time did not show a significant difference ($p<0.05$) from these negative relationships, and all other swimming style performances studied showed a significant change ($p<0.05$). In the study conducted by Siders et al. (1993), they suggested that there was a negative relationship between swimming performance and lean body weight as well as body weight. Again, in the study conducted by Espada et al. (2023) on university swimmers, they reported that swimming performance was negatively correlated with body fat percentage. It has also been reported that higher lean mass in swimmers means that they have higher propulsion force and better swimming performance (Cochrane et al., 2015). Another study (Sammoud et al., 2019) revealed that body mass does not affect 100 m backstroke swimming performance. Body weight is affected by water, bone.

Recommendations

As in all branches, correct selection and guidance are very important in swimming. The physical characteristics included in the study can be used as

indicators in the selection of athletes. However, it is thought that it would be useful to conduct this study on high-level swimmers

Kısaltmalar / Abbreviations

SPSS Statistical Package for the Social Sciences

p value Probability value

n Number of People

Beyanlar / Declarations

Etik Onay ve Katılım Onayı / Ethics approval and consent to participate

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The preparation and writing process of this study have been conducted in full compliance with the scientific, ethical, and citation principles outlined in the "Directive on Scientific Research and Publication Ethics of Higher Education Institutions." No manipulation or falsification has been carried out on the collected data, and this study has not been submitted for evaluation to any other academic publication platform. The author assumes full responsibility for any potential violations related to the article. The research process was initiated following the approval granted by the Ethics Committee of the Bayburt University (Date: 07.01.2025, Reference No: 2025/8.

Veri Ve Materyal Erişilebilirliği / Availability of data and material

Bu çalışmanın bulgularını destekleyen veriler, makul talepler üzerine sorumlu yazardan temin edilebilir. Veri seti yalnızca akademik amaçlar için erişilebilir olacak ve verilerin herhangi bir kullanımı, orijinal çalışmayı referans gösterecek ve katılımcıların gizliliğini koruyacaktır.

The data that support the findings of this study are available from the corresponding author upon reasonable request. The dataset will be accessible only for academic purposes, and any use of the data will recognize the original study and maintain the confdentiality of the participants.

Çıkar Çatışması / Competing interests

Yazarlar, bu makalede sunulan çalışmayı etkileyebilecek herhangi bir çıkar çatışması veya kişisel ilişkiye sahip olmadıklarını beyan etmektedirler.

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Yazar Katkıları / Author contributions

Design and planning of the study: H.B.T; Data collection, analysis or interpretation: H.B.T., M.Ü; Writing the article: H.B.T; Data organization, method determination, writing – original draft, writing – review and editing: H.B.T., M.Ü; All authors have critically reviewed the manuscript for essential points. All authors have approved the final version of the manuscript.

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References / Kaynaklar

Akınoğlu, B., Şener, O. A., Hasanoğlu, A., Kocahan, T. (2021). Examining the Relationship Between Foot Length and Ankle Muscle Strength in Swimmers. Turkish Journal of Sport and Exercise /Türk Spor ve Egzersiz Dergisi; 23(3): 314-319

Aspenes, ST, Karlsen, T. (2012). Exercise-training intervention studies in competitive swimming. Sports Med.42:527-43.

Berger MA, Hollander AP, De Groot G. (1997). Technique and energy losses in front crawl swimming. Med Sci Sports Exerc. 1997 Nov;29(11):1491-8. doi: 10.1097/00005768-199711000-00016. PMID: 9372487.

Bongard V, McDermott AY, Dallal GE, Schaefer EJ. (2007). Effects of age and gender on physical performance. Age (Dordr). Sep;29(2-3):77-85. doi: 10.1007/s11357-007-9034-z. Epub Jun 23. PMID: 19424833; PMCID: PMC2267663.

Bond, D., Goodson, L., Oxford, S. W., Nevill, A. M., & Duncan, M. J. (2015). The Association between Anthropometric Variables, Functional Movement Screen Scores and 100 m Freestyle Swimming Performance in Youth Swimmers. *Sports*, *3*(1), 1-11. https://doi.org/10.3390/sports3010001

Bouchard C, Malina RM, Hollmann W, Leblanc C. (1976). Relationships between skeletal maturity and submaximal working capacity in boys 8 to 18 years. Med Sci Sports. 8(3):186–90. doi: 10.1249/00005768-197600830-00010.

Cochrane, K.C., Housh, T.J., Smith, C.M., Jenkins, N.D., Johnson, G.O., Housh, D.J., Smith, R.J., Cramer, J.T. (2015). Relative contributions of strength, anthropometric, and body composition characteristics to estimated propulsive force in young male swimmers. J Strength Cond Res. 2015;29(6):1473–1479. doi: 10.1519/JSC.0000000000000942. [DOI] [PubMed] [Google Scholar]

Charmas, M., Gromisz, W., (2019). Effect of 12-Week Swimming Training on Body Composition in Young Women. Int J Environ Res Public Health. Jan 26;16(3):346. doi: 10.3390/ijerph16030346. PMID: 30691153; PMCID: PMC6388213.

Charles, J.D., Bejan, A. (2008). The evolution of speed, size and shape in modern athletics. J Exp Biol. 212(15):2419–2425. doi: 10.1242/jeb.031161. [DOI] [PubMed] [Google Scholar]

Chengalur, S.N., Brown, P.L. (1992). An analysis of male and female Olympic swimmers in the 200-meter events. Can J Sport Sci. 17(2):104–109.

Çağlar, EC, Yıldırım, T., Kutlu, M., Camici, F., & Özkaldı, T. (2024). Genç yüzücülerde 400 metre serbest stilde antropometrik ve motor özellikler ile yüzme performansı arasındaki ilişki. ROL Spor Bilimleri Dergisi, 5 (2), 323–338. https://doi.org/10.5281/zenodo.12600274

Dempsey, J.A., Seals, D.R. (1995). Aging, exercise, and cardiopulmonary function. Perspectives in Exercise Science and Sports Medicine: Volume 8 Exercise in Older Adults, Lamb DR, Gisolfi CV, Nadel E. 237304 Cooper Publishing Carmel, IN

Donato, A. J., Tench, K., Glueck, D. H., Seals, D. R., Eskurza,I. Tanaka, H. (2003). Declines in physiological functional capacity with age: alongitudinal study in peak swimming performance. J Appl Physiol (1985).February;94(2): 764–769. doi:10.1152/japplphysiol.00438.2002

Espada, M.C., Ferreira, C.C., Gamonales, J.M., Hernández-Beltrán, V., Massini, D.A., Macedo, A.G., Almeida, T.A.F., Castro, E.A., Pessôa Filho, D.M. (2023). Body Composition Relationship to Performance, Cardiorespiratory Profile, and Tether Force in Youth Trained Swimmers. Life (Basel). Aug 24;13(9):1806. doi: 10.3390/life13091806. PMID: 37763210; PMCID: PMC10532630.

Fernandes, R., Aleixo, I., Soares, S., & Vilas-Boas, J. P. (2008). "Anaerobic Critical Velocity: A New Tool for Young Swimmers Training Advice." Physical Activity and Children: New Research 211–23.

Geladas, N.D., Nassis, G.P., Pavlicevi, S. (2005). Somatic and physical traits affecting sprint swimming performance in young swimmers. Int J Sports Med. 26(2):139–144. doi: 10.1055/s-2004-817862. [DOI] [PubMed] [Google Scholar]

Hlavaty, R. (2010). The anthropometric and kinematic determinants of swimming performance. Joint International IGIP-SEFI Annual Conference Trmava; Slovakia.

Khosla, T. (1984). Physique of female swimmers and divers in the 1976 Montreal Olympics. JAMA. 252(4):536–537.

Ihsan, F.M., Slamet Riyadi, S. (2022). The Contribution of Leg Length, Leg Muscle Strength, Arm Span and Maximum Oxygen Volume to 100-Meter Crawl Swimming Achievement. International Journal of English Literature and Social Sciences Vol-7, Issue-1; Jan-Feb.

Jürimäe J, Haljaste K, Cicchella A, Lätt E, Purge P, Leppik A, Jürimäe T. (2007). Analysis of swimming performance from physical, physiological, and biomechanical parameters in young swimmers. Pediatr Exerc Sci. Feb;19(1):70-81. doi: 10.1123/pes.19.1.70. PMID: 17554159.

Kwon, Y. H., Casebolt, J. B. (2006). Effects of light refraction on the accuracy of camera calibration and reconstruction in underwater motion analysis. Sports biomechanics, 5(2), 315-340.

Lätt E, Jürimäe J, Mäestu J, Purge P, Rämson R, Haljaste K, Feskinen K, Rodriguez FA, Jürimäe T. (2010). Physiological, biomechanical and anthropometrical predictors of sprint swimming performance in adolescent swimmers. J Sports Sci Med. 2010;9(3):398–404. [PMC free article] [PubMed] [Google Scholar]

Lohman, T.G., Roche, A.F. and Martorell, R. (1988) Anthropometric standardization reference manual. Human Kinetics Books, Chicago.

Marinho, Daniel Almeida, Abel I. Rouboa, Francisco B. Alves, Nuno D. Garrido, João Paulo Vilas-Boas, Tiago M. Barbosa, Victor Machado Reis, António Moreira, and António José Silva. 2007. "Modelos Propulsivos: Novas Teorias Velhas Polémicas." Universidade de Trás-Os-Montes e Alto Douro 205.

Marinho, D., Silva, A., Rouboa, A., Soons, B., Persyn, U., Vilas-Boas, J.P., Barbosa, T. M., Reis, V., Moreira, A. (2007). Modelos propulsivos: novas teorias velhas polémicas. Vila Real: Universidade de Trás-os-Montes e Alto Douro. ISBN 978-972-669-796-1

Martinez-Garcia, A., Rosell-Mele, A., Jaccard, S. L., Geibert, W., Sigman, D. M., Haug, G. H. (2011). Southern Ocean dust-climate coupling over the past four million years. *Nature*, *476*(7360), pp312-U141(5). https://doi.org/10.1038/nature10310

Morais, J.E., Jesus, S., Lopes, V., Garrido, N., Silva, A., Marinho, D., Barbosa, T.M. (2012). Linking selected kinematic, anthropometric and hydrodynamic variables to young swimmer performance. Pediatr Exerc Sci. Nov;24(4):649-64. doi: 10.1123/pes.24.4.649. PMID: 23196769.

Öztürk, L., Aktan, A., Varol, T. (1997). İşlevsel Anatomi. Saray Medikal Yay. San.ve Tic.Ltd.Şti. 1.Baskı. Bornova, İzmir

Saavedra, J.M., Escalante, Y., Rodriguez, F.A. (2010). A multivariate analysis of performance in young swimmers. Pediatr Exerc Sci. 22:135-51.

Sammoud, S., Nevill, A.M., Negra, Y., Bouguezzi, R., Helmi, C., Hachana, Y. (2019). Key somatic variables in young backstroke swimmers. J Sports Sci. May;37(10):1162-1167. doi: 10.1080/02640414.2018.1546547. Epub 2018 Nov 15. PMID: 30430909.

Scorțenschi, D. (2019). "Development of Speed Qualities by Improving Swimming Technique Elements Using Technical Means." Ştiinţa Culturii Fizice 1(33):79–82

Solomon, E. P. (1999). İnsan Anatomisine ve Fizyolojisine Giriş, Çeviri: Bikem, L. 2.Baskı. Birol Yayıncılık: İstanbul

Siders, W.A., Lukaski, H.C., Bolonchuk, W.W. (1993). Relationships among swimming performance, body composition and somatotype in competitive collegiate swimmers. J Sports Med Phys Fitness. Jun;33(2):166-71. PMID: 8412052.

Stanula, A., Maszczyk, A., Roczniok, R., Pietraszewski, P., Ostrowski, A., Zając, A., Strzała, M. (2012). The Development and Prediction of Athletic Performance in Freestyle Swimming. J Hum Kinet. 32:97–107. doi: 10.2478/v10078-012-0027-3. [DOI] [PMC free article] [PubMed] [Google Scholar]

Vantorre, Julien, Didier Chollet, and Ludovic Seifert. 2014. "Biomechanical Analysis of the Swim-Start: A Review." Journal of Sports Science and Medicine 13(2):223–31.

Zampagni M, Casino D, Benelli P, Visani A, Marcacci M, De Vito G.. Anthropometric and strength variables to predict freestyle performance times in elite master swimmers. J Strength Cond Res. 2008;22(4):1298–1307. doi: 10.1519/JSC.0b013e31816a597b. [DOI] [PubMed] [Google Scholar]

Zuniga, Jorge, Terry J. Housh, Mielke Michelle, C. Russell Hendrix, Clayton L. Camic, Glen O. Johnson, Dona J. Housh, and Richard J. Schmidt. 2011. "Gender Comparisons of Anthropometric Characteristics of Young Sprint Swimmers." Journal of Strength and Conditioning Research 25(1):103–8

Willems TM, Cornelis JA, De Deurwaerder LE, Roelandt F, De Mits S. The effect of ankle muscle strength and flexibility on dolphin kick performance in competitive swimmers. Human Movement Science, 2014;36:167-176

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