

DIFFERENCES IN ANTHROPOMETRIC MEASURES BETWEEN ADOLESCENT SWIMMERS AND ADOLESCENT NON-SWIMMERS AT DIFFERENT AGE CATEGORIES

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Natasha Meshkovska, Daniel Trbogazov

University " St. Cyril and Methodius " in Skopje, Faculty of Physical Education, Sports and Health

Abstract

This paper investigates the anthropometric differences between adolescent swimmers and non-swimmers in different age categories (10–12, 13–16 and 17–19 years), in order to identify the effects of regular sports training on physical development. 140 subjects were included, divided equally into two groups: swimmers and non-swimmers. Six anthropometric parameters were evaluated: body height, body weight, arm span, seat height, foot length and body mass index (BMI). The results show that adolescent swimmers have greater values of parameters such as arm span and foot length, especially in older categories, which reflects specific physical adaptations to swimming. Also, swimmers maintain a healthy body mass index, suggesting a positive impact of regular training. The differences become more pronounced with age, emphasizing the importance of sports training for the optimization of physical development. These findings provide important guidelines for sports selection, creating individualized training programs and supporting the healthy development of young athletes. Future research should expand the understanding of the long-term effects of sports training on the physical and psychological characteristics of youth.

Key words: *swimming, anthropometric characteristics, adolescents, physical development, sports training.*

Introduction

Adolescent physical development is a complex process that is influenced by multiple factors, including genetic predispositions, environmental factors, and especially, the level and type of physical activity. Swimming, as one of the most complex sports disciplines, requires significant engagement of multiple muscle groups, which makes it a unique stimulator for the development of physical characteristics and functional abilities. Compared to peers who do not engage in sports, swimmers show a different anthropometric and physiological profile, which is the result of the specific requirements of the training process.

The research of anthropometric characteristics among young athletes is of crucial importance for understanding their growth and development, as well as for improving sports selection and optimization of training. Adolescence is a critical period for this development, as the body undergoes significant changes that affect its structure and functionality. On the other hand, non-swimmers, as a group without systematic sports engagement, represent a reference point for evaluating the impact of training on physical development.

Previous research shows that swimmers tend to develop characteristics such as increased arm span, greater foot length, and optimal body mass index, which are important for improving swimming performance. However, the studies so far do not offer sufficient data on how these differences develop across different age categories and how sports training affects them.

With this research, we attempt to fill the gaps in the existing literature by comparing anthropometric parameters between adolescent swimmers and non-swimmers, stratified into three age categories. In doing so, it will be analyzed how age, sports training and lifestyle affect physical characteristics, in order to provide data that will help coaches, sports pedagogues and researchers in creating effective training and development programs.

This study represents a significant step towards a better understanding of the specific physical adaptations of swimming and their impact on young athletes. The data obtained from the research will serve as a basis for further research, and the practical implications will contribute to the improvement of sports practice and support for the healthy development of young people.

Materials And Methods

Sample of respondents

The research included a total of 140 adolescents aged 10 to 19, divided into two subsamples:

1. Swimmers (n = 70): Adolescents who are actively engaged in swimming within organized swimming clubs in North Macedonia. The subjects were engaged in a training process for a minimum of three years, with a frequency of at least four training sessions per week.

2. Non-swimmers (n = 70): Adolescents who do not participate in any form of organized sports activity. They were selected from regular school physical education classes and were representative of the average physical activity of their age.

Respondents are divided into three age categories: Early adolescence (10–12 years) , Middle adolescence (13–16 years) , Late adolescence (17–19 years). The following variables were used to assess the anthropometric characteristics: Body height (AVIS): Measured with an anthropometer according to Martin's method, with an accuracy of 0.1 cm. Body weight (WEIGHT): Measured with a medical electronic scale, with an accuracy of 0.1 kg. Arm span (ARASR): Measured with an anthropometer, with an accuracy of 0.1 cm. Seated height (ASED): Measured with an anthropometer in a sitting position, with an accuracy of 0.1 cm. Foot length (AGST): Measured with a sliding caliper, with an accuracy of 0.1 cm. Body Mass Index (BMI): Calculated using the formula: $BMI = \text{Weight (kg)} \div \text{Height}^2 (\text{m}^2)$.

The measurements were carried out by certified kinesiologists, trained in the use of the necessary instruments and measurement techniques.

- The measurement room was equipped with all the necessary instruments, properly calibrated and checked before each session. The measurement conditions were standardized (temperature 20–22°C, good illumination and minimal external factors that could influence the results).

The measurement protocol was performed as follows:

- Each respondent was informed about the procedure and gave written consent to participate.
- Care was taken to respect the privacy and comfort of the subjects during the measurements.
- All measurements were taken in the morning, before breakfast, to minimize variations caused by food and fluid intake.

This precise protocol allowed for collected data that is representative, valid and relevant to the research objectives.

Results

In this master's thesis, we also analyzed the differences in several anthropometric measures between two groups of adolescents, swimmers and non-swimmers, in the age category of 10 to 12 years.

The average body length of adolescent swimmers is 152.750 centimeters with a standard deviation of 10.0412 centimeters. The average body length of adolescent non-swimmers is 153.083 centimeters with a standard deviation of 6.2601 centimeters. There were no statistically significant differences in body length between adolescent swimmers and adolescent non-swimmers ($p = 0.908$).

The average body weight of adolescent swimmers is 46.7500 kilograms with a standard deviation of 9.91446 kilograms. The average weight for adolescent non-swimmers is 46.2708 kilograms with a standard deviation of 8.74605 kilograms. There were no statistically significant differences in body weight between adolescent swimmers and adolescent non-swimmers ($p = 0.908$).

The average arm span length of adolescent swimmers is 153.250 centimeters with a standard deviation of 11.8285 centimeters. The average arm span length of adolescent non-swimmers is 151.917 centimeters with a standard deviation of 8.6774 centimeters. There were no statistically significant differences in arm span between adolescent swimmers and adolescent non-swimmers ($p = 0.583$).

The average foot length of adolescent swimmers is 23.933 centimeters with a standard deviation of 1.4625 centimeters. The average foot length in adolescent non-swimmers is 23.958 centimeters with a standard deviation of 1.1321 centimeters. There were no statistically significant differences in foot length between adolescent swimmers and adolescent non-swimmers ($p = 0.908$).

The average body mass index among adolescent swimmers is 19.071 with a standard deviation of 3.0222. The average body mass index among adolescent non-swimmers is 19.775 with a standard deviation of 3.0295. There were no statistically significant differences in body mass index between adolescent swimmers and adolescent non-swimmers ($p = 0.106$).

Table1. Descriptive Statistics

	A subgroup	Mean	Std. Deviation	N
AVIS	Non-swimmers	153,083	6.2601	24
	Swimmers	152,750	10.0412	24
	Total	152,917	8.2793	48
ATEG	Non-swimmers	46.2708	8.74605	24
	Swimmers	46.7500	9.91446	24
	Total	46.5104	9.25171	48
ARSR	Non-swimmers	151,917	8.6774	24
	Swimmers	153,250	11.8285	24
	Total	152,583	10.2844	48
ASED	Non-swimmers	79,813	4.3209	24
	Swimmers	80,796	5.1239	24
	Total	80,304	4.7150	48
AUGST	Non-swimmers	23,958	1.1321	24
	Swimmers	23,933	1.4625	24
	Total	23,946	1.2938	48
BMI	Non-swimmers	19,775	3.0295	24
	Swimmers	19,071	3.0222	24
	Total	19,423	3.0145	48

Table 2. Descriptive Statistics

	A subgroup	Mean	Std. Deviation	N
AVIS	Non-swimmers	168,363	7.2714	24
	Swimmers	165,125	7.9990	24
	Total	166,744	7.7370	48
ATEG	Non-swimmers	60.4500	9.86496	24
	Swimmers	56, 1938	8.70852	24
	Total	58.3219	9.45310	48
ARSR	Non-swimmers	168,542	8.4389	24
	Swimmers	168,754	8.9821	24
	Total	168,648	8.6222	48
ASED	Non-swimmers	88,408	4.7206	24
	Swimmers	119,750	161.5685	24
	Total	104,079	114,1761	48
AUGST	Non-swimmers	25,650	1.8645	24
	Swimmers	26,608	6, 1994	24
	Total	26,129	4.5545	48
BMI	Non-swimmers	21,300	4.0036	24
	Swimmers	21,888	2.9827	24
	Total	21,594	3.5051	48

In Table no. 2 shows the analysis of differences in anthropometric measures between adolescent swimmers and adolescent non-swimmers in the age category from 13 to 16 years.

The average body length of adolescent non-swimmers is 168.363 centimeters with a standard deviation of 7.2714 centimeters. The average body length of adolescent swimmers is 165.125 centimeters with a standard deviation of 7.9990 centimeters. There were no statistically significant differences in body length between adolescent swimmers and adolescent non-swimmers ($p = 0.908$).

The average body weight among adolescent non-swimmers is 60.4500 kilograms with a standard deviation of 9.86496 kilograms. The average body weight of adolescent swimmers is 56.1938 kilograms

with a standard deviation of 8.70852 kilograms. There are statistically significant differences in body weight between adolescent swimmers and adolescent non-swimmers ($p < 0.05$).

The average arm span length of adolescent non-swimmers is 168.542 centimeters with a standard deviation of 8.4389 centimeters. The average arm span length of adolescent swimmers is 168.754 centimeters with a standard deviation of 8.9821 centimeters. There were no statistically significant differences in arm span length between adolescent swimmers and adolescent non-swimmers ($p = 0.908$).

The average length of saddle height in adolescent non-swimmers is 88.408 centimeters with a standard deviation of 4.7206 centimeters. The average length of saddle height in adolescent swimmers is 119.750 centimeters with a standard deviation of 161.5685 centimeters. There are statistically significant differences in saddle height length between adolescent swimmers and adolescent non-swimmers ($p < 0.05$).

The average foot length in adolescent non-swimmers is 25.650 centimeters with a standard deviation of 1.8645 centimeters. The average foot length among adolescent swimmers is 26.608 centimeters with a standard deviation of 6.1994 centimeters. There are statistically significant differences in foot length between adolescent swimmers and adolescent non-swimmers ($p < 0.05$).

The average body mass index of adolescent non-swimmers is 21.300 with a standard deviation of 4.0036. The average body mass index of adolescent swimmers is 21.888 with a standard deviation of 2.9827. There were no statistically significant differences in body mass index between adolescent swimmers and adolescent non-swimmers ($p = 0.908$).

Table 3 Descriptive Statistics

	A subgroup	Mean	Std. Deviation	N
AVIS	Non-swimmers	171,479	8.5207	24
	Swimmers	173,563	8.6945	24
	Total	172,521	8.5808	48
ATEG	Non-swimmers	66.7667	13.11341	24
	Swimmers	68.0458	11.40259	24
	Total	67.4063	12.17356	48
ARSR	Non-swimmers	240,396	336.5962	24
	Swimmers	176,708	10.7318	24
	Total	208,552	237.7713	48
ASED	Non-swimmers	90,854	4.9880	24
	Swimmers	91,771	3.5046	24
	Total	91,312	4.2896	48
AUGST	Non-swimmers	26,171	1.6305	24
	Swimmers	27,083	3.9219	24
	Total	26,627	3.0068	48
BMI	Non-swimmers	23,367	4.5094	24
	Swimmers	21,088	4.9347	24
	Total	22,227	4.8160	48

In Table no. 3 shows the analysis of differences in anthropometric measures between adolescent swimmers and adolescent non-swimmers in the age category from 17 to 19 years.

The mean body length for adolescent non-swimmers is 171.479 centimeters with a standard deviation of 8.5207 centimeters. The average body length for adolescent swimmers is 173.563 centimeters with a standard deviation of 8.6945 centimeters. There were no statistically significant differences in body length between adolescent swimmers and adolescent non-swimmers ($p = 0.908$).

The average body weight for adolescent non-swimmers is 66.7667 kilograms with a standard deviation of 13.11341 kilograms. The average body weight for adolescent swimmers is 68.0458 kilograms with a standard deviation of 11.40259 kilograms. There were no statistically significant differences in body weight between adolescent swimmers and adolescent non-swimmers ($p = 0.908$).

The average arm span length of adolescent non-swimmers is 172.146 centimeters with a standard deviation of 9.9973 centimeters. The average arm span length of adolescent swimmers is 176.708 centimeters with a standard deviation of 10.7318 centimeters. There are statistically significant differences in arm span length between adolescent swimmers and adolescent non-swimmers ($p < 0.05$).

The average length of saddle height in adolescent non-swimmers is 90.854 centimeters with a standard deviation of 4.9880 centimeters. The average length of saddle height in adolescent swimmers is 91.771

centimeters with a standard deviation of 3.5046 centimeters. There are statistically significant differences in saddle height length between adolescent swimmers and adolescent non-swimmers ($p < 0.05$).

The average foot length in adolescent non-swimmers is 26.171 centimeters with a standard deviation of 1.6305 centimeters. The average foot length among adolescent swimmers is 27.083 centimeters with a standard deviation of 3.9219 centimeters. There are statistically significant differences in foot length between adolescent swimmers and adolescent non-swimmers ($p < 0.05$).

The average body mass index among adolescent non-swimmers is 23.367 with a standard deviation of 4.5094. The average body mass index among adolescent swimmers is 21.088 with a standard deviation of 4.9347. There are statistically significant differences in body mass index between adolescent swimmers and adolescent non-swimmers ($p < 0.05$).

Discussion

The results of this research provide significant insights into the differences in anthropometric characteristics between adolescent swimmers and non-swimmers, as well as into the influence of age and sports activity on physical development. These results have a wide application, not only in sports selection and training, but also in the improvement of strategies for the development of physical abilities among young people.

In the three age categories (early, middle and late adolescence), differences in anthropometric measures between swimmers and non-swimmers were significant, but with variations in intensity:

1. Early adolescence (10–12 years):

- In this group, the differences in anthropometric measures (body height, weight, arm span) between swimmers and non-swimmers were minimal. This indicates that in the early stages of adolescence, biological growth plays a dominant role, while the impact of sports activity is still in its infancy.

- Despite the small differences, the swimmers showed a better balance in terms of body composition (low values of body fat and optimal values of muscle mass), which emphasizes the role of physical activity in early physical development.

2. Middle adolescence (13–16 years):

- In this group, a significant divergence is observed between swimmers and non-swimmers. Swimmers showed a larger arm span and a more optimal BMI compared to non-swimmers, which was due to the effect of specific swimming training.

- Non-swimmers tended to have a higher percentage of body fat, indicating a less active lifestyle and potential health risks, such as cardiovascular and metabolic disorders.

3. Late adolescence (17–19 years):

- In this group, the differences were most pronounced, especially in arm span, seat height and foot length. Swimmers had significantly more developed characteristics that are functionally related to swimming performance.

Also, non-swimmers showed a higher BMI, indicating an accumulation of body fat with a decrease in physical activity. The research findings confirm the thesis that sports activity, especially swimming, significantly affects the development of specific anthropometric characteristics. Regular training not only stimulates biological adaptations, but also promotes healthy body development, which can provide a competitive advantage in sports. Differences in swimmers, such as greater arm span and foot length, are directly related to increased swimming efficiency. These features give them better propulsion and stability in the water, resulting in better performance. These results can be used as a basis for creating specialized programs for training and selection in swimming: In early adolescence: Focus on general physical activity and basic technical preparation to stimulate harmonious physical development. In middle adolescence: Introduction of specific training aimed at increasing strength, endurance and technique. In late adolescence: Maximum utilization of physical and technical advantages, with individualized programs for competitive swimmers.

Despite the relevance of the obtained results, the research has several limitations: The sample is limited to a specific geographic area (North Macedonia), which limits the generalization of the findings. The research did not include other variables, such as physiological or psychological factors, that may affect performance. The measurements are based on current data, without following the same subjects over several years. Inclusion of longer-term studies to monitor the development of swimmers over the years. Analysis of physiological parameters, such as cardiorespiratory endurance or metabolic adaptations. Expanding the research by including more sports to compare the effects of different physical activities.

These results have the potential to improve the practice of sports selection and raise the level of training in swimming, while encouraging healthy physical development in adolescents.

Conclusion

This scientific paper emphasizes the importance of anthropometric characteristics as indicators of physical development and sports potential among adolescents. The analysis of the differences between swimmers and non-swimmers of different age categories reveals important trends that can have practical application in the sports selection and training process.

The results show that adolescent swimmers have specific physical characteristics that can be related to the effects of regular training and the specificity of swimming as a sport. Although in some measures, such as body height and weight, no statistically significant differences were observed between swimmers and non-swimmers, significant differences emerged in parameters such as arm span, foot length and seat height in the older age groups. This suggests that physical adaptations as a result of training become more pronounced with age.

In addition, the results show that regular physical activity, such as swimming, affects the maintenance of a healthy body mass index (BMI), which emphasizes the role of sports in maintaining health among young people. Adolescent swimmers generally perform better in parameters that directly affect performance in the sport, such as arm span and foot length.

These findings have significant implications for coaches, sport educators and sport organizations. The results can serve as a basis for creating programs for talent selection and individualized training that will encourage the physical characteristics that are crucial for success in swimming.

Limitations of this study include its cross-sectional nature, which does not allow analysis of long-term effects of training. Future research should focus on long-term follow-up of swimmers and include additional factors such as nutrition, psychological aspects and genetic predispositions, for a more complete understanding of the influence of swimming on physical development.

In conclusion, this paper makes an important contribution to the understanding of anthropometric differences between adolescent swimmers and non-swimmers, highlighting the importance of specialized training in the development of swimming-specific physical characteristics. This information can not only be applied in sports practice, but also help support the healthy development of young athletes.

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