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Original research article

MORPHOLOGICAL CHARACTERISTICS AND FUNCTIONAL ABILITIES IN PREDICTING PERFORMANCE INSYNCHRONIZED SWIMMING

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Abstract. *The main purpose of this research was to determine to what extent some of the characteristics of female athletes in synchronized swimming hypothetically explains their results and offers predictions. The research was conducted on 30synchronized swimmers, height 165.49±3.57cm and body weight of 53±4.23kg who regularly train and compete in the junior level of championship (age 16 to 18).Variables of the participants' morphological characteristics were obtained by the analysis of their body composition by using the method of bioelectrical impedance (BIA).Variables of functional skills were based on four tests. Variables for the evaluation of the performance of figures consisted of two basic and two selected figures according to the FINA rule book. The data analysis was done by the use of SPSS 20.0. Each variable result was presented as the basic central and dispersion parameters. The obtained results of the analysis of variance (ANOVA) show that there is a difference between the two groups of participants according to the all the research spaces. The research found a certain number of connections that were expected having in mind the nature of morphological and functional skills involved in performance in all the tested subspaces. The obtained results refer to some further research which will enable better understanding of the body functions of synchro swimmers. The results of this research are practically applicable in higher qualitative preparation of the synchro swimmers and achieving top results.*

Key words: *synchro swimming, body composition, functional skills, result efficiency*

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INTRODUCTION

Improving the system of preparation of synchronous swimmers is not possible without finding new approaches and methodological solutions in the organization of the training process and it is necessary to apply modern scientific achievements to synchronized swimming in the practical work of coaches. In order to achieve the ultimate goal, and in modern sport that is the final result of the competition, it is necessary to assess the impact of external and internal factors on the prognosis and achievement of results. First of all, it is important to establish the level of potentials that are important for synchronized swimming and then load the swimmers based onthe appropriate training technology that will result in great success. The training process and other external factors of influence should be directed to the objectives arising from the model characteristic of a synchronous swimmer (Ahmetović, 2013). In order to define the model characteristics of synchronous swimmers, it is necessary to determine the physiological, biochemical, biophysical and all other mechanisms that determine the individual differences in motor capabilities of swimmers and then determine how much we can really affect these potentials by the resources that are at our disposal. Based on the analysis of the results achieved in competition, we can single out the factors which determine the efficiency and results in synchronized swimming (Tošić, Kocić, & Andrejić, 2010; Tošić, Aleksić, Delibašić, Aleksandrović, & Aleksić, 2011; Mendes dos Santos et al., 2013; Perić, Cavar, Zenić, Sekulić, & Sajber, 2014). Numerous studies in synchronized swimming show the impact of a number of factors, such as: physiological (Chen et al., 2010; Alentejano, Marshall, & Bell, 2010; Alentejano, Bell, & Marshall, 2012; Schaal et al., 2013; Rodrigez-Zamora et al., 2014; Robertson, Benardot, & Mountjoy, 2014), morphological (Yamamura et al., 1999; Tanaka, Homma, Kawahaua, & Murata, 2004; Šajber, Perić, Spasić, Zenić, & Sekulić, 2013; Perić et al., 2014), biomechanical (Gordeeva, 2012; Homma, 2010; Diogo et al., 2010), technical (Homma & Homma, 2005; Homma & Homma, 2006; Ito, 2006; Stanković, Mekić, Aleksić, & Delibašić, 2012; Winiarski, Dubiel Wuchowicz, & Rutkowska-Kucharska, 2013; Gomes et al., 2014) and motor aspects (Yamamura et al., 1999; Perić, Petrić, & Žižić, 2007; Chen et al., 2010; Perić & Spasić, 2010; Tošić et al., 2010), that have resulted in the formation of a specific matrix of characteristics of top athletes, both quantitatively and qualitatively modeled so as to provide a high level of predisposition to achieve top results in synchronized swimming. The guiding idea for this research comes precisely from the fact that the results of this research can be of great importance for all coaches and experts in this field and in promoting and organizing the very training in synchronized swimming. Participants aged 16 to 18 are the representatives of the junior category in synchronized swimming. The junior category was primarily chosen because of the appropriate training experience and with the level of technique which is the result of many years of preparation. On the other hand, competition in the figures is the most important part of the competition in synchronized swimming because performing figures represents the achieved technical level of swimmers and their functional - motor abilities. The high technical level of the figures makes it easier to perform free and technical compositions. Therefore this research is focused on the connection between the characteristics of synchronous swimmers and the result efficiency, because today more than ever, training work, methods, resources and loads must be directed towards the development of the structure of characteristics thanks to which swimmers are more likely to achieve maximum results.

METHODS

Sample of participants

The study included 30 female synchronized swimmers, with a body height of 165.49± 3.57cm and body weight of 53±4.23kg which are training regularly and compete in junior competitions of the Synchronized Swimming Federation of Serbia's current competition system (16 up to 18 years of age).The sample of 30 participants was divided into two separate sub-samples - according to the values of the criterion variable.

Sample of measuring instruments

The variables for the assessment of body structure: body height (AVIS), body weight (AMAS), body mass index (BMI), body fat percentage (Bodyfat %)andmuscle mass percentage (Muscle %).

Variables for the assessment of functional skills: Static apnea (STA),dynamic no fins (DNF), gliding (GLID) (Morais et al., 2013) and swimming 400 m freestyle (P400K) (According to FINA rules 2013-2017).

The criterion variable is the final result of the National Synchronized Swimming Championship (figures) - (FINA rules 2013 - 2017).

Data processing method

Data processing was performed in the program SPSS 20.0. The results of this research were processed in a way so that the information about the central and dispersion parameters for all the studied variables could be obtained, as follows: the arithmetic mean (*Mean*), standard deviation (*SD*), skewness *(Skew.*) and kurtosis *(Kurt.*). In order to test the significance of the differences in arithmetic means, the univariate analysis of variance (*ANOVA*) was performed for each group of participants. In order to determine the impact of motor skills, body composition and tests for specific motor skills on the final result, a regression analysis was conducted.

RESULTS

By taking a look at Table 1, which shows the results of the central and dispersion parameters of applied variables and the methods of analysis of variance (*ANOVA*), the

Table 1 Descriptive indicators and the significance of differences between the groups of participants

Variables	Mean	SD	Skew.	Kurt.	Mean	SD	Skew.	Kurt.	F	Sig.
	Group 1 (n=15)				Group 1 (n=15)				ANOVA	
HEIGHT (cm)	161,31	5,92	-,50	-,13	164,10	4,62	-,41	-,67	2,07	,161
MASS (kg)	48,76	5,29	,01	-1,04	53,83	5,41	-,03	-1,42	6,74	**,015**
BMI (kg/m²)	18,48	1,49	,16	,47	19,89	1,78	,91	,18	5,54	**,026**
BODYF (%)	20,64	3,29	-,21	-,88	21,48	4,27	-,97	1,25	,36	,551
MUSC (%)	34,98	1,56	-,27	-1,18	34,36	1,91	,54	,45	,94	,339
STA (s)	105,72	12,18	,336	-,901	70,33	13,63	-,812	-,260	56,192	**,000**
DNF (m)	51,66	12,15	,491	-,916	37,60	6,05	,883	,732	16,103	**,000**
GLID (m)	6,13	,75	1,135	1,263	4,40	,68	-,420	-1,043	43,234	**,000**
P400K (s)	283,14	16,39	,399	-1,819	305,28	10,08	-2,288	7,335	19,862	**,000**
RANG	57,24	2,68	1,02	,81	49,60	2,38	-,24	-1,05	67,94	**,000**

Legend: arithmetic mean (Mean), standard deviation (SD), skewness (Skew.), kurtosis (Kurt.).

differences in the mean valuesAVIS, AMAS and BMI of the variables between the groups of participants can be observed in all the examined fields.

Table 2 The result of the regression analysis - the relationship between morphological characteristics and the final result

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	F	Sig.
1	,591[a]	,349	,245	4,011	3,350	**,025[a]**

Legend: R- multiple correlation; R Square- predictive validity of the whole system; Adjusted R square individual - predictive value; F, F-ratio; p-statistical significance of the influence of the whole reduced system of variables

Table 3 The influence of the system of predictive variables on the criterion variable (RANG).

Variables	B	Std. Error	Beta	t	Sig.
HEIGHT (cm)	,214	,362	,250	,592	,560
MASS (kg)	-,734	,588	-,931	-1,249	,224
BMI (kg/m²)	-,086	1,425	-,033	-,060	,952
BODYF (%)	1,419	,521	1,160	2,722	**,012**
MUSC (%)	1,886	,991	,712	1,903	,069

Table 4 The result of the regression analysis - the relationship between motor skills and the final result

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	F	Sig.
1	,956[a]	,914	,900	1,46078	66,145	,000[a]

Legend: R- multiple correlation; R Square- predictive validity of the whole system; Adjusted R square individual - predictive value; F, F-ratio; p- statistical significance of the influence of the whole reduced system of variables

Relations between the functional abilities of swimmers and the criterion RANG variable are summarized in Table 4. The obtained multiple correlation coefficient R = .956 indicates that the system of predictor variables has a significant impact on achieving success in synchronized swimming. According to the value of the square of multiple correlation R^2, which amounts to .914, we can conclude that the system of predictor variables explains 91.4% of the total variance, while the remaining 8.6% belong to the area of other factors that are not included in this study.

Table 5 The influence of the system of predictive variables on the criterion variable (RANG).

Variables	B	Std. Error	Beta	t	
STA (s)	,084	,024	,401	3,528	**,002**
DNF (m)	,065	,036	,166	1,812	,082
GLID (m)	1,364	,391	,334	3,486	**,002**
P400K (s)	-,046	,022	-,176	-2,130	**,043**

DISCUSSION

The body shape is not an element of evaluation, yet the appearance and body composition represent the primary focus of coaches and athletes in synchronized swimming. In addition to the intensive trainings and the aesthetic nature of the sport itself, the nutritional requirements of female synchronized swimmers are also complex (De Sousa Fortes, Neves, Filgueiras, Almeida, & Ferreira, 2013; Sundgot-Borgen, & Garthe, 2011; Robertson, Benardot, & Mountjoy, 2014). The descriptive statistical indicators of the analyzed groups of participants, in terms of motor skills, indicate certain differences. We came across similar results in the studies of many authors.

Previous studies have proven that female swimmers with greater height, due to the longer levers, achieve better results (Tanaka et al., 2004; Rovnaya, Podrigalo, Ermakov, Kristof, & Ceslicka, 2014). Studies of individual authors show that the body mass index and body fat percentage are not statistically significant variables for achieving success in the competition (De Sousa Fortes at al., 2013; Sundgot-Borgen, & Garthe, 2011; Robertson et al., 2014). Therefore, the results of these studies suggest the impossibility of predicting success in synchronized swimming on the basis of variables that estimate the body composition of female swimmers (Tošić et al., 2010; Tošić, 2011; Perić et al., 2014; Mendes dos Santos et al., 2013). On the other hand, a large number of studies suggest that the monitoring of the body composition of female swimmers is necessary at all stages of control of female swimmers' condition.

The results from Table 1 indicate that the participants from the first group have an average height of 161.31±5.92cm and body weight of 48.76±5.29kg, which means that they are 2.79cm lower and 7.07kg lighter than the second group of participants. The difference between the two groups of participants is observed in the body mass index, which is 18.48±1.49kg/m² for the first group of participants and 19.89±1.78kg/m² for the second group of participants. If we compare the obtained data with the international table, the "Cut off points" which define the body weight and obesity, we can observe that the mean values in both groups of participants are in the healthy zone. The second group of participants has higher values of body fat percentage (21.48±4.27%), while both groups of participants have equal values of muscle mass percentage - 34%.A significant difference between the groups of participants were not observed in the following variables: body height (.161), body fat percentage (.551) and muscle mass percentage (.339).

The relationship between the systems of variables for the evaluation of morphological characteristics and the dependent variable of the ranking (Table 2) is relatively high (R= .591). The common variability between the predictor system and the criterion variable is about 35% (R^2= .349). There is a statistically significant relationship between the predictor system and the criteria (p= .025). The remaining 65% in explaining the total variability can be attributed to other skills and characteristics of the participants, which were not included in this regression analysis. Previous studies have proven that female swimmers with greater height, due to the longer lever, achieve better results (Tanaka et al., 2004; Rovnaya, et al., 2014). Studies of individual authors show that the body mass index and body fat percentage are not statistically significant variables for achieving success in the competition (De Sousa Fortes, Neves, Filgueiras, Almeida & Ferreira, 2013; Sundgot Borgen & Garthe, 2011; Robertson, Benardot & Mountjoy, 2014). Therefore, the results of these studies suggest the impossibility of predicting success in synchronized swimming on the basis of variables that estimate the body composition of female swimmers (Tošić et al., 2010; Tošić, 2011; Perić

et al., 2014; Mendes dos Santos et al., 2013). On the other hand, a large number of studies suggest that the monitoring of the body composition of female swimmers is necessary at all stages of control of female swimmers' condition.

Numerous studies indicate that the monitoring of body composition of swimmers is necessary at all stages of control of swimmer condition. The individual contribution of variables is statistically significant for the variable BODF. Research results of the author Tanaka et al. (2004), Pyne & Sharp (2014) and Dodigović & Sindik (2015) conclude that synchronous swimmers are often tall, with an emphasis on thinness. The obtained results show that synchronous swimmers tend to have more muscles and less fat in the body. According to the research of Šajber et al. (2013), anthropometric characteristics (body height, body mass, subcutaneous fat and the amount of body fat) are not significantly associated with competition results in synchronized swimming (criterion).

For this sample of participants, the results showed a positive correlation between the amount of fat in the body (p=,012) and result efficiency (Table 3). It is not difficult to explain these results given the very characteristics of synchronized swimming. The amount of fat in the body should not always be seen as a negative characteristic. Body fat has a lower density than water and therefore a higher percentage of fat content in the body enables most part of the body to be above the water surface (Perić et al., 2012), which is of great importance for the performance of figures. These results suggest that it is necessary to apply the method of BIA within the testing of swimmers in all the categories to be able to, based on the obtained results, draw concrete conclusions regarding the physical composition of the participants. More studies need to be focused on all the anthropometric features of swimmers and aspects of a sports diet which can be of great importance for synchronous swimmers.

Predictor variables STA, DNF, GLID, P400K, statistically significantly influence the final ranking. The individual contribution of the predictor set of variables indicates that statistically variables endurance in apnea p=,002, skating p=,002 and swimming 400m freestyle p=,043 have a significant effect on the criterion variable (Table 5).

Bearing in mind that a large number of studies (Naranjo, Centeno, Carranza, & Cayetano, 2006; Alentejano et al., 2010; Quan, Culver, & Fielding, 2010; Chen et al., 2010; Robertson et al., 2014) have confirmed that the functional capabilities are of crucial importance for the result efficiency of swimmers, it is essential to include in the training process all the exercises with longer retention in apnea, which would contribute to increasing the level of functional abilities in synchronous swimmers. The participants who had higher scores on these tests were better placed in the final ranking. The research of the authors Rovnaya et al. (2014) also indicates that the functional abilities are in the correlation with the results of the competition. Their results show that specific training processes in synchronized swimming contribute to the large differences in functional abilities in favor of synchronous swimmers, in relation to the participants of the same age who are not in the training process. Authors Gabrilo, Perić, & Stipić (2011) conclude in their research efforts that lung functions greatly contribute to competitive achievements in synchronized swimming. A statistically significant effect on the achieved competition results was showed by a diving test in the research of Zenić, Roguljić, & Grčić-Zubčević (2005). The authors conclude that swimming and diving continue to play a vital role in the preparation and training of synchronous swimmers.

CONCLUSION

Based on the results of this research, we can draw several conclusions. In the field of morphologic characteristics, the results show that they are not essential for achieving maximum results. The regression analysis showed that the common variability of the predictor system and the criterion variable is 35%. Therefore, the results of this study suggest the impossibility of predicting success in synchronized swimming on the basis of variables that estimate the body composition of swimmers. Based on the obtained results of the regression analysis of the manifest space of functional abilities, we can conclude that the system of predictor variables explains 91.4% of the total variance. Working in apnea is an integral part of training and competition in synchronized swimming and therefore the high level of the influence of functional abilities on the result efficiency of a synchronous swimmer is not surprising. Due to the specificity of the very work in apnea, it is especially important to emphasize that research works related to this mode of work of synchronous swimmers would be of great importance. Given that this kind of work in apnea potentially carries a high risk, a number of scientific research papers would contribute to a better organization of the training process of synchronous swimmers for work in apnea. The fact is that the further progress of science will enable a better understanding of the functioning of the body of synchronous swimmers. Discovering new scientific achievements within this sport or the use of better training means will contribute to the improved preparation of competitors and thus enable achieving top results.

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MORFOLOŠKE KARAKTERISTIKE I FUNKCIONALNE SPOSOBNOSTI U PREDIKCIJI USPEŠNOSTI U SINHRONOM PLIVANJU

Osnovni cilj ovog istraživanja bio je utvrditi u kojoj meri određeni broj obeležja sinhronih plivačica hipotetski objašnjava rezultate i nudi predikciju. Istraživanjem je obuhvaćeno 30 sinhronih plivačica, telesne visine 165.49±3.57cm i telesne mase 53±4.23kg koje su u redovnom trenažnom procesu i takmiče se u juniorskoj konkurenciji (uzrasta od 16 do 18 godina). Varijable morfoloških karakteristika dobijene su analizom telesnog sastava ispitanica metodom bioelektrične impedance (BIA). Varijable za procenu funkcionalnih sposobnosti ustanovljene su pomoću četiri testa. Varijable za procenu izvođenja figura obuhvatale su dve osnovne i dve izvučene figure prema FINA pravilniku. Obrada podataka izvršena je pomoću statističkog programa SPSS 20.0. Za svaku varijablu prikazani su osnovni centralni i disperzioni parametri. Dobijeni rezultati analize varijanse (ANOVA) pokazuju da postoji razlika između grupa ispitanica u odnosu na sve istraživane prostore. U istraživanju je dobijen veći broj veza koje su očekivane s obzirom na bliskost prirode morfološkog i funkcionalnog ispoljavanja u svim testiranim subprostorima. Dobijeni rezultati nameću potrebu za organizovanjem novih istraživanja koja će omogućiti bolje razumevanje funkcionosanja organizma sinhronih plivačica. Rezultati ovog istraživanja od velike su praktične primenljivosti, doprineće kvalitetnijoj pripremi takmičarki a samim tim i omogućiti postizanje vrhunskih rezultata.

Ključne reči: *sinhrono plivanje, telesni sastav, funkcionalne sposobnosti, rezultatska efikasnost*