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Original empirical article

THE INFLUENCE OF FLEXIBILITY ON SWIMMING RESULTS

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Abstract. *In order to determine the impact of flexibility on the results in swimming, we conducted a study on a sample of 50 female patients aged 11 to 14. The study included 50 female participants with an average body weight of 51.9±7.1 kg and an 163.9±10.5 cm. Their average age was 12.7±1.1 years, training experience was 3.7±0.66 years, and the body mass index (BMI) was 19.3±1.9. The participants all took part in the training process in the swimming clubs "Niš 2005" and "Sveti Nikola", Niš, Serbia. The study was applied to 17 measuring instruments that were divided into three groups: Measuring instruments for the assessment of flexibility (11); Measuring instruments for the assessment of swimming results (4); Measuring instruments for the evaluation of morphological characteristics (2). A canonical-correlation analysis was used to determine the relation between flexibility and performance in swimming, and the regression analysis determined the impact of flexibility on the results in swimming. The canonical- correlation analysis did not demonstrate a single significant feature that would allow, without reservation, the confirmation of the assumptions about the significant relations between flexibility and performance in swimming. The regression analysis did not confirm the assumption that there is a statistically significant effect of flexibility variables on the results in swimming for female swimmers.*

Key words: *motor skills, flexibility, flexibility and swimming, results in swimming, female swimmers.*

INTRODUCTION

Due to numerous pieces of information that have been obtained over the past few years and the constant changes taking place in international sport, we are able to clearly delineate the current topics in competitive swimming, which include: the incessant im-

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provement in swimming technique, the improvement in the training method, finding practical use for knowledge and the role that human dynamics play (Okičić, 2001, 130).

Scientific research has helped to develop certain programs, but most of these studies have been of little or no use to the swimmer himself (Colwin, 1998, 210).

Many factors, whose influence can be felt but not easily measured, influence swimming success, in addition to the existing anthropometric characteristics (height, weight, the length of the extremities, the distribution of muscle mass), and vital capacity (Pivač, 1998; Madić et al., 2007; Okičić et al., 2007).

Due to the limitations in the abilities which are dominant in the performance of a certain swimming task, it is necessary to become familiar with the differences in the anthropological characteristics of young boys and girls (Pavić et al., 2008, 830). Since there are many disciplines in swimming, a special model needs to be made for each of them, in relation to age, gender and the discipline in question. The parameters which are monitored in all age categories are mostly related to anthropometric characteristics and skills.

The research of many authors (Kapus, 1982; Vidović et al., 1989; Volčanšek, 1996; Colwin, 1998; Okičić, 2001; Zenić et al., 2007) indicates that the parameters of height and weight are present in swimming and that their interrelationship, depending on the extent, has an effect on swimming results.

The motor space of swimmers is divided into factors which are directly or indirectly present in the realization of the basic kinesiological activity. Each motor dimension has, up till now, had a role that has not sufficiently been described (Colwin, 1998, 21).

Cureton (1947) was the first to point out the marvelous flexibility of top swimmers (taken from Colwin, 1998, 196). The 1970s saw increased interest in the topic.

Depending on the structure of the movement which is conditioned by the swimming technique, great differences were noted in the mobility of certain joints. Decreased tonus in a horizontal position, time spent in warm water, the active cycling work mode, the constant friction created by the water during movement, long term involvement in swimming and the frequency of two-day training sessions are all factors which influence the increase in the flexibility of the shoulder, pelvic and ankle joint and knee joint. Swimming training sessions are focused on the increase of mobility, since the increase leads to the improvement of results in certain techniques (Volčanšek, 1986, 17).

The METHOD

The sample of participants

The sample of participants was extracted from a population of young girls aged 11 to 14, who were taking part in the training process in the swim clubs “Niš 2005” and “Sveti Nikola” from Niš, Serbia. The study included 50 female participants with an average body weight of 51,9±7,1 kg and average height of 163,9±10,5 cm. Their average age was 12,7±1.1 years, average training experience was 3,7±0,66 years, and body mass index (BMI) was 19,3±1,9. All of the participants trained regularly at their clubs and had a sports career of at least three years.

Measuring instruments

The morphological characteristics were descriptively presented by means of the following measuring instruments: body height (AVIS), body mass (AMAS) and the body mass index (BMI) (in accordance with the International Biological Program, according to Đurašković, 2001).

The predictor set of variables is presented by means of the measuring instruments used to evaluate flexibility: the measuring instruments for the evaluation of flexibility of the hand and shoulder belt: the step forward (MFLISK), hands extended to the back in a kneeling position (MFLONK), the reverse thrust (MFLPRG); the measuring instruments used to evaluate leg flexibility: stepping forward from a supine position (MFLPLK), stepping backwards from a prone position (MFLZLP), legs spread apart in a lying position (MFLRLK), plantar flexion (MFLPFS); the measuring instruments used to evaluate the flexibility of the trunk: leg raising lying on the side (MFLOLB), hyperextensions on a bench (MFLPRK), hyperextensions legs apart (MFLPRR) and hyperextensions with a band (MFLPRT) (the selection and description of the measuring instruments was carried out on the basis of the research carried out up to date (Kurelić et al., 1975; Metikoš et al., 1989; Šoše & Rađo, 1998; American College of Sport Medicine, 2006; Vivian, 2006)).

The criterion set of variables is represented by the following set of measuring instruments used to evaluate swimming results: the 100 m freestyle (P100K), the 100 m breaststroke (P100P), the 100 m backstroke (P100L) and the 100 m butterfly (P100D).

Data processing methods

The results of this research have been processed in such a way so as to obtain information regarding the central and dispersion parameters for all of the manifest variables, including: the minimal results obtained during measuring (*Min.*), the maximum results obtained during measuring (*Max.*), the average values (*Mean*), standard deviation (*SD*) and range (*Range*).

In order to determine the relations between flexibility and swimming results, the canonical correlation analysis was used.

In order to determine the influence of flexibility on swimming results, the regression analysis was used. The regression analysis was used to determine the significance of the relation and extent of the influence that the variables used to evaluate flexibility had on the criterion variables used to evaluate swimming results.

The interpretation of the results of the regression analysis includes: determining whether the entire system of predictor variables is significant for the process of predicting criterion variables (the following values were determined: the level of significance (p), the determinant coefficient (R^2) and the multiple correlation coefficient (R).

The results and the discussion

The basic statistical parameters of flexibility and the swimming results.

Table 1 The descriptive statistics

	N	Mean	Min	Max	Range	SD	Error	Skew	Kurt
MFLISK	50	53.0	31.0	84.0	53.00	14.56	2.06	0.46	-0.85
MFLONK	50	83.7	59.0	101.0	42.00	6.87	0.97	-0.82	2.86
MFLPRG	50	49.3	38.0	56.0	18.00	4.35	0.61	-0.65	0.18
MFLPLK	50	110.0	83.0	142.0	59.00	14.35	2.03	0.01	-0.97
MFLZLP	50	58.3	31.0	86.0	55.00	14.04	1.99	-0.03	-0.43
MFLRLK	50	108.7	80.0	136.0	56.00	14.07	1.99	-0.04	-0.63
MFLOLB	50	98.3	73.0	123.0	50.00	13.58	1.92	-0.13	-1.01
MFLPRK	50	-16.8	-30.0	-2.0	28.00	6.15	0.87	0.35	-0.48
MFLPRR	50	62.1	36.0	76.0	40.00	9.09	1.29	-0.73	0.27
MFLPRT	50	19.9	4.0	46.0	42.00	9.74	1.38	0.39	-0.11
MFLPFS	50	21.4	13.0	29.0	16.00	4.15	0.59	-0.02	-0.91
P100D	50	91.7	75.0	115.0	40.00	9.31	1.32	0.68	0.04
P100L	50	93.7	76.0	117.0	41.00	9.44	1.34	0.23	-0.40
P100P	50	100.7	90.0	118.0	28.00	7.73	1.09	0.54	-0.56
P100K	50	85.5	67.0	111.0	44.00	10.33	1.46	0.68	-0.07
AVIS	50	162.1	144.0	187.3	43.30	8.46	1.20	0.35	1.01
AMAS	50	49.6	36.0	68.0	32.00	6.02	0.85	0.26	0.77
BMI	50	18.9	15.1	25.6	10.50	1.61	0.23	1.78	5.09

By analyzing Table 1, which shows the results of the central and dispersion parameters of the applied variables, we can determine that there are great ranges between the minimal and maximal results obtained during the testing. The sample of female participants used in this study was extracted from a population of female swimmers aged 11 to 14.

Even though we are dealing with a selected sample, it is obvious that the female participants differ from each other significantly both in terms of their morphological and their motor and specific swimming skills. It is well known that biological age influences the state of motor skills. Since the changes in morphological makeup are also greatly prominent during the period when there is increased growth and development, these changes can influence the reduction in the results in some of the motor tests. By analyzing table 1, we can also conclude that there are no significant deviations from the normal distribution, considering the fact that the values of skewness (*Skew*) do not exceed 1.00, and the fact that they are neither too great (*Skew* < 1.00) nor too little (*Skew* >1.00) and are suited to the population of selected female swimmers.

The value of kurtosis (*Kurt*) was, in the case of all of the variables except for the variable hands extended to the back in a kneeling position (MFLONK), significantly below the normal value of the distribution (2.75), which indicates that the results were widely dispersed. The dispersion of the results is not surprising, in view of the already presented explanations related to the great individual differences in the development of the female participants. In the case of most of the variables (8) the curve was platykurtic, while in the case of breaststroke (P100P), stepping forward from a supine position (MFLPLK), legs spread apart in a lying position (MFLRLK), plantar flexion of the feet (MFLPFS), the step forward (MFLISK) and body height (AMAS) it was moderately mesokurtic. In the case of the variables hands extended to the back in a kneeling position (MFLONK), body height (AVIS) and leg raising lying on the side (MFLOLB) the curve was mesokurtic.

Table 2 The cross-correlation matrix.

	P100D	P100D	P100D	P100D
MFLISK	0.05	0.04	-0.11	0.07
MFLONK	-0.08	0.01	-0.15	-0.04
MFLPRG	0.04	0.04	0.02	-0.01
MFLPLK	-0.10	-0.10	-0.12	-0.05
MFLZLP	-0.07	-0.20	-0.12	-0.04
MFLRLK	0.13	-0.00	0.07	0.14
MFLOLB	-0.10	-0.07	0.05	0.05
MFLPRK	0.14	0.06	0.10	0.08
MFLPRR	0.14	0.07	0.07	0.19
MFLPRT	-0.05	0.02	-0.10	-0.08
MFLPFS	-0.05	-0.01	-0.17	0.05

Table 2 shows the simple linear correlation between the set of tests used to evaluate flexibility and swimming results for the 100 m swim for all four types of techniques. The analysis has shown that there is no statistically significant connection between the swimming techniques and the variables.

In the research carried out so far, it has been shown that the swimming speeds for the freestyle and for the backstroke are dominated by arm and shoulder strength, segmentary speed and endurance. The influence of flexibility is also present, but is less significant in the studies carried out by Madić et al. (2001) and Leko (2001). The research results of Zenić et al. (2006) indicate that explosive strength correlates with swimming results, and that the influence of flexibility is quite small.

The regression analysis

Table 3 The regression analysis of the predictor system and criterion variable P100D

Variables	*R*	*Part-R*	*BETA*	*St. Err.*	*t(3 8)*	*p-level*
MFLISK	0.05	0.13	0.09	0.11	0.80	0.43
MFLONK	-0.08	-0.01	-0.01	0.24	-0.04	0.97
MFLPRG	0.04	-0.05	-0.13	0.41	-0.31	0.75
MFLPLK	-0.10	-0.18	-0.18	0.16	-1.11	0.27
MFLZLP	-0.07	-0.05	-0.05	0.15	-0.31	0.75
MFLRLK	0.13	0.21	0.20	0.16	1.30	0.20
MFLOLB	-0.10	-0.20	-0.20	0.15	-1.27	0.21
MFLPRK	0.14	0.17	0.34	0.33	1.04	0.30
MFLPRR	0.14	0.28	0.47	0.26	1.80	0.07
MFLPRT	-0.05	-0.09	-0.13	0.22	-0.58	0.56
MFLPFS	-0.05	-0.10	-0.27	0.43	-0.63	0.53
	$R= 0.46$	$R^2= 0.21$	$F(11.38)=0.94$		$p<0.52$	

Table 3 shows the results for the connection between the system of variables used to evaluate flexibility and the dependent variable the 100 m butterfly (P100D). By analyzing the obtained results, it can be concluded that there is no statistically significant connection between the predictor system and the criterion (p<0.52). The connection between the predictor system and the criterion variable can be explained by means of the multiple correlation coefficient **(**R= 0.46), and the determinant coefficient **(**R^2= 0.21) which indicates 21% of common information. The remaining 79% of the information used in the explanation of the overall variability of the criterion variable can be ascribed to other anthropological characteristics and skills not included in the study (for instance, other motor skills, morphological variables, motivation, anthropometric characteristics and the like).

In their research, Sugimoto et al. (2008) obtained information that plantar flexion and the influence of the angle of the plantar flexion on the submerged leg kick in the butterfly is important, but is not decisive.

Table 4 The regression analysis of the predictor system and criterion variable P100L

Variables	*R*	*Part-R*	*BETA*	*St. Err.*	*T(88)*	*p-level*
MFLISK	0.04	0.06	0.05	0.12	0.38	0.71
MFLONK	0.01	0.07	0.12	0.26	0.45	0.66
MFLPRG	0.04	-0.03	-0.09	0.44	-0.21	0.83
MFLPLK	-0.10	-0.02	-0.03	0.17	-0.15	0.88
MFLZLP	-0.20	-0.26	-0.26	0.16	-1.63	0.11
MFLRLK	-0.00	0.06	0.06	0.17	0.37	0.72
MFLOLB	-0.07	-0.04	-0.04	0.16	-0.27	0.79
MFLPRK	0.06	0.02	0.04	0.36	0.11	0.91
MFLPRR	0.07	0.22	0.38	0.28	1.36	0.18
MFLPRT	0.02	0.01	0.01	0.24	0.04	0.97
MFLPFS	-0.01	-0.17	-0.49	0.47	-1.05	0.30
	R= 0.34	R^2= 0.12	F(11.38)=0.47		p<0.91	

Table 4 shows the results for the connection between the system of variables used to evaluate flexibility and the dependent variable the 100 m backstroke (P100L).

By analyzing the obtained results, we can conclude that there is no statistically significant connection between the predictor system and the criterion (p<0.91).

The connection between the predictor system and the criterion variable is explained by means of the multiple correlation coefficient **(**R= 0.34), as well as the determinant coefficient (R^2= 0.12) which indicates that 12% of the overall variability of the dependent variable can be explained by means of the influence of the combined independent variables, while the remaining 88% of the variability can be explained by the influence of unidentified factors.

The research of Šiljet et al. (2006) has shown that the hand extension test (25-m pool) has the greatest predictive strength for the evaluation of the 100m and 200m backstroke, which was expected considering the specific nature of the backstroke and the importance of hand movement during its performance. These tests used to evaluate the flexibility of the shoulder joint of the swimmer were not used in this study.

Table 5 shows the results of the connection between the system of variables used to evaluate flexibility and the dependent variable the 100 m breaststroke (P100P).

Table 5 The regression analysis of the predictor system and criterion variable P100P.

Variables	*R*	*Part-R*	*BETA*	*St. Err.*	*T(88)*	*p-level*
MFLISK	-0.11	-0.06	-0.03	0.10	-0.36	0.72
MFLONK	-0.15	0.01	0.02	0.20	0.08	0.94
MFLPRG	0.02	-0.02	-0.04	0.35	-0.10	0.92
MFLPLK	-0.12	-0.15	-0.12	0.13	-0.91	0.37
MFLZLP	-0.12	-0.21	-0.17	0.13	-1.35	0.18
MFLRLK	0.07	0.06	0.05	0.13	0.35	0.73
MFLOLB	0.05	0.11	0.09	0.13	0.69	0.50
MFLPRK	0.10	0.16	0.28	0.28	1.02	0.32
MFLPRR	0.07	0.12	0.17	0.22	0.77	0.44
MFLPRT	-0.10	-0.18	-0.21	0.19	-1.10	0.28
MFLPFS	-0.17	-0.23	-0.54	0.37	-1.47	0.15
	R= 0.44	R^2= 0.19	F(11.38)=0.83		p<0.61	

By analyzing the obtained results we can conclude that there is no statistically significant connection between the predictor system and the criterion ($p<0.61$). The influence of every test result on the evaluation of flexibility is especially small, and on the basis of the obtained results we can conclude that the results obtained during the tests did not indicate either an individual or group statistically significant influence on the criterion variable, which leads us to the conclusion that on the basis of motor skill of flexibility we cannot predict the results for the 100 m breaststroke race.

The connection between the predictor system and the criterion variable is explained by the multiple correlation coefficient (R= 0.44), as well as the determinant coefficient (R^2= 0.19) which indicates 19% of the common information. The remaining 81% of the information in the explanation of the overall criterion variable can be ascribed to other characteristics and abilities which were not included in the study.

The values of the regression coefficients and the partial correlations at the univariate level indicate that none of the variables which were used to evaluate flexibility have a significant influence on the manifestation of the criterion variable.

Table 6. The regression analysis of the predictor system and the criterion variable P100K.

Variables	*R*	*Part-R*	*BETA*	*St. Err.*	*t(88)*	*p-level*
MFLISK	0.07	0.12	0.10	0.13	0.74	0.46
MFLONK	-0.04	-0.01	-0.02	0.28	-0.08	0.93
MFLPRG	-0.01	-0.05	-0.14	0.48	-0.30	0.77
MFLPLK	-0.05	-0.14	-0.16	0.18	-0.90	0.38
MFLZLP	-0.04	-0.07	-0.08	0.17	-0.45	0.65
MFLRLK	0.14	0.16	0.18	0.18	0.99	0.33
MFLOLB	0.05	-0.05	-0.05	0.18	-0.29	0.77
MFLPRK	0.08	0.14	0.33	0.38	0.86	0.40
MFLPRR	0.19	0.24	0.47	0.30	1.56	0.13
MFLPRT	-0.08	-0.05	-0.09	0.26	-0.34	0.74
MFLPFS	0.05	-0.03	-0.09	0.50	-0.18	0.86
	R = 0.39	R^2 = 0.15	F(11.38)= 0.63		p<0.79	

Table 6 shows the results of the connection between the system of variables for the evaluation of flexibility and the dependent variable the 100 m swim freestyle.

By analyzing the obtained results we can conclude that there is no statistically significant connection between the predictor system and the criterion ($p<0.79$). The connection between the predictor system and the criterion variable is explained by the multiple correlation coefficient ($R= 0.39$), as well as the determinant coefficient ($R^2= 0.15$) which indicates that 15% of the overall variability of the dependent variable can be explained by the influence of combined independent variables, while the remaining 85% of the variability is under the influence of factors which were not included in this study.

The values of the regression coefficients and the partial correlations at the univariate level indicate that none of the individual variables used to evaluate flexibility have a significant influence on the criterion variable.

The results obtained by means of the regression analysis indicate that flexibility (the predictor system) does not have a statistically significant influence on all of the variables which were used to evaluate swimming results. The obtained results indicate that there is no possibility for predicting the success in swimming on the basis of flexibility.

THE CONCLUSION

This research was carried out with the aim of determining the influence of flexibility on swimming results in the case of female swimmers. The sample of female swimmers consisted of 50 participants aged from 11 to 14. The sample of variables consisted of 11 tests used to evaluate flexibility and 4 tests used to evaluate swimming results. In order to determine the inter-relations between the studied variables, we used a correlation analysis, while the influence between the studied variables was determined by means of a regression analysis.

On the basis of the obtained indicators we can conclude that the motor skill of flexibility is not a statistically significant predictor in swimming in the case of all four techniques in the 100 m race for the female swimmers of the selected age group. Considering the fact that flexibility is one of the motor skills which should have a positive correlation with success in swimming, it is obvious that on the basis of these results, the development of flexibility has not receiving enough attention, which should be rectified in future research projects.

The generalization of the results obtained in this research is applicable only to the sample of subjects included in this study. The longitudinal monitoring of a greater number of swimmers would give a more complete image of the swimming results and the influence flexibility has on them. In addition, the research should also include other swimming disciplines, where flexibility would probably manifest its influence. This study provides the basis for further research which could be more successful if it included a greater number of participants or analyze other swimming disciplines.

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UTICAJ FLEKSIBILNOSTI NA REZULTATE U PLIVANJU

Slađana Tošić

Sa ciljem da se utvrdi uticaj fleksibilnosti na rezultate u plivanju, sprovedeno je istraživanje na uzorku od 50 ispitanica uzrasta od 11 - 14 godina. Njihova prosečna starost bila je 12,7±1.1 godina, trenažni staž 3,7±0,66 godina, telesna visina 163,9±10,5 cm, telesna masa 51,9±7,1 kg, indeks telesne mase (BMI) 19,3±1,9. Ispitanice su u trenažnom procesu u plivačkim klubovima "Niš 2005" i "Sveti Nikola" iz Niša, Srbija.. U istraživanju je primenjeno 17 mernih instrumenata koji su bili podeljeni u tri grupe: Merni instrumenti za procenu fleksibilnosti (11); Merni instrumenti za procenu rezultata u plivanju (4); Merni instrumenti za procenu morfoloških karakteristika (2). Kanonočko-korelaciona analiza je korišćena u cilju utvrđivanja relacija između fleksibilnosti i rezultata u plivanju, dok je regresionom analizom utvrđen uticaj fleksibilnosti na rezultate u plivanju. Kanoničko-korelacionom analizom nije dobijena ni jedna značajna funkcija koja bi dozvoljavala, bez rezerve, potvrđivanje pretpostavke o značajnim relacijama između fleksibilnosti i rezultata u plivanju. Regresiona analiza nije potvrdila pretpostavku da postoji statistički značajn uticaj varijabli fleksibilnosti na rezultate u plivanju kod plivačica.

Ključne reči: *motoričke sposobnosti, fleksibilnost, fleksibilnost i plivanje, rezultati u plivanju, plivačice.*