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Original research article

THE EFFECTS OF ADDITIONAL STRENGTH TRAINING ON SPECIFIC MOTOR ABILITIES IN YOUNG SWIMMERS

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Abstract. *The aim of this study was to determine the effects of dry-land strength training on motor abilities specific for swimming among young swimmers aged 10-14 years. The participant sample comprised 60 swimmers, aged 10-12 and 13-14, divided into two experimental and two control groups. The measures included 16 variables for assessing specific motor abilities in the disciplines of the 100m freestyle and breaststroke. The experimental exercise program lasted 12 weeks. Compared to the control groups, the experimental groups had additional dry-land strength training targeting large muscle groups of the entire body. After the applied experimental program, statistically significant effects were identified in the form of improvements to the following variables: start time for the 10m breaststroke, stroke length in the breaststroke, and turn length in the breaststroke for swimmers aged 10-12, whereas for swimmers aged 13-14 there was an improvement in the variable stroke efficiency in the freestyle. Based on the total analysis, we conclude that the applied experimental program would require modification in the further training process with a view to achieving more considerable training effects which would in turn lead to a more significant transformation of the swimming results in the categories of swimmers aged 10-12 and 13-14.*

Key words: *dry-land training, motor abilities, swimming results.*

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INTRODUCTION

There have always been efforts in swimming, as in other sports, to discover anything that might influence and contribute to the achievement of ever better results in competitions. The increasing demands placed before swimmers in the training process have led researchers and coaches to dedicate themselves to researching this area. That the science of swimming is making more progress and that further studies are constantly needed is evidenced by the results achieved in major competitions. Such progress is explained both by the enhancing and perfecting of swimming techniques and by the ever-improving physical and psychological fitness of the swimmers (Pešić, 2009).

Motor abilities constitute one of the fundamental factors for all human movement and motion. Whether they are acquired via exercise or not, they are a factor in solving motor tasks and making successful movement possible (Malacko & Rađo, 2004).

Strength as a basic motor ability has a significant effect on young swimmers' development, and on the achievement of top results. Therefore, according to Sweetenham & Atkinson (2003), dry-land training is used with a view to developing general physical fitness, specifically strength and flexibility. This is in line with Volčanšek's call for dedicating 25% of the basic training program to dry-land practice and 75% to in-water practice for young swimmers aged 10 to 14 (Volčanšek, 2002).

The demands for the development of a swimmer's strength are influenced by the nature and duration of dynamic efforts in the process of competitive swimming activity (Madić, Okičić, Rašović & Okičić, 2011). According to Volčanšek (1996) and Kazazović (2008), a swimmer should exhibit maximal strength, explosive strength and endurance in strength. Maximal strength is developed because of the importance of a swimmer's general physical fitness. Explosive strength plays an important role in the performance of the start jump and turn, whereas endurance is developed for cyclical stroke repetitions in swimming. Which type of strength is needed more will vary depending on the swimming discipline and technique. Maximal and explosive strength are important in all shorter-distance swimming techniques, from 50 to 200 meters, whereas endurance is more important in swimming 800m and 1,500m freestyle (Volčanšek, 1996).

In accordance with the aforementioned, the aim of this study was to determine the effects of dry-land strength training on motor abilities specific for swimming, for swimmers in the age categories 10-12 and 13-14.

METHOD

The participants

The participants in this study included 60 swimmers aged 10 to 14 years who had practiced swimming actively for at least 3 years in the swimming clubs Niš 2005 and Sveti Nikola in Niš, Serbia. The participants were divided into two experimental groups, E1 (10 to 12 years of age) and E2 (13-14 years), and two control groups in the same respective age ranges. All of the testing was done in accordance with the ethical principles of conducting research on human subjects as specified in the 2008 Helsinki Declaration (WMA, 2011).

Table 1 Basic data on the participants in all groups at the initial and final testing

Variables	E1		C1		E2		C2	
	ini.	fin.	ini.	fin.	ini.	fin.	ini.	fin.
Height	1,63±0,68	1,66±0,57	1,55±0,10	1,58±0,10	1,69±0,08	1,71±0,08	1,68±0,05	1,70±0,05
Weight	52,34±6,58	55,00±6,81	45,75±9,39	47,9539,4	58,55±10,46	62,69±10,10	59,24±0,04	61,72±6,96
Bmi	19,78±2,86	19,89±2,22	18,77±2,58	19,07±2,41	20,21±2,57	21,29±2,46	21,01±2,38	21,34±2,50

Measures

All of the testing was conducted in a 50m-long Olympic-size pool and in the gym of the sports center Čair in Niš.

Specific motor skills testing

The following tests were used for the assessment of motor abilities specific for swimming: the start time for the 10m freestyle (StaT10C) and breaststroke (StaT10B), duration of the 10m freestyle (SwT10C) and breaststroke (SwT10B), turn time for the 5 + 5m freestyle (TTC) and breaststroke (TTB), freestyle stroke length (SLC) and breaststroke (SLB), freestyle stroke efficiency (SEC) and breaststroke (SEB), freestyle stroke number (SNC) and breaststroke (SNB), freestyle start length (StaLC) and breaststroke (StaLB), freestyle turn length (TLC) and breaststroke (TLB). Test descriptions were adopted from Okičić (1999), Jorgić, Okičić, Stanković, Dopsaj, Madić et al. (2011), as well as Đurović, Beretić, Dopsaj, Pešić & Okičić (2012).

Procedures (experimental treatment)

Two groups of swimmers, an experimental one and a control one, took part in the experiment. The experimental groups (E1 and E2) trained following a specific training plan and program, including a combination of in-water and dry-land strength training. The control groups (C1 and C2) trained following only the plan and program of swimming practice in water, with no dry-land practice.

The experimental program lasted for 12 weeks, while the training process was divided into three mesocycles related to the intensity and range of the exercises. Within each mesocycle, the training process was divided into 4 micro-cycles (week). The plan for the experimental program is shown in Table 2.

For the control group there was no additional strength training on dry land. The exercise program applied during the in-water swimming practice, as well as the weekly schedule, is shown in Table 3.

Table 2 Experimental training process plan

week	1	2	3	4	5	6	7	8	9	10	11	12
month		December				January				February		
objective	developing general strength and endurance in water and on dry land											
testing	initial											Fin.
tr. days	6	6	6	6	6	6	6	6	6	6	6	6
rest day	1	1	1	1	1	1	1	1	1	1	1	1
practice no.	10	10	10	10	10	10	10	10	10	10	10	10
pool	6	6	6	6	6	6	6	6	6	6	6	6
dry-land	4	4	4	4	4	4	4	4	4	4	4	4
hr.no (min.)	540	540	540	540	600	600	600	600	660	660	660	660
pool (min.)	360	360	360	360	420	420	420	420	480	480	480	480
dry (min.)	180	180	180	180	180	180	180	180	180	180	180	180
range												
pool (E_1C_1/E_2C_2) (range in km)	15/ 18	15/ 18	15/ 18	15/ 18	16.5/1 9.2	16.5/ 19.2	16.5/ 19.2	16.5/ 19.2	18/ 21	18/ 21	18/ 21	18/ 21
Dry practice series	104	104	104	104	104	104	104	104	104	104	104	104
intensity												
pool	E_1C_1 - 2.5 km/h E_2C_2 – 3 km/h				E_1C_1 - 2.75 km/h E_2C_2 – 3.2 km/h				E_1C_1 - 3 km/h E_2C_2 – 3.5 km/h			
dry	60sec (20sec work/ 40sec break)				60 sec (30sec work/ 30sec break)				60sec (40sec work/ 20sec break)			

Table 3 The exercise program to be applied in swimming practice

	pool	
Monday	Butterfly, backstroke, start	Exercises for body position, arm work, leg work, coordination, lift during takeoff, entry into water, and gliding
Tuesday	Breaststroke, freestyle, turn	Exercises for body position, arm work, leg work, coordination, turn, push, transitioning into swimming
Wednesday	Medley	Coordination exercises for butterfly, backstroke, breaststroke, freestyle
Thursday	Butterfly, backstroke, start	Exercises for body position, arm work, leg work, coordination, press during takeoff, lift during takeoff, entry into water, and gliding
Friday	Breaststroke, freestyle, turn	Exercises for body position, arm work, leg work, coordination, turn, push, transitioning into swimming, gliding
Saturday	Time trial medley (speed)	Measuring time for each swimming style
Sunday	Rest	

The strength training program, along with the exercise range, is shown in Table 4.

Table 4 Strength training program with the exercise range

Days	No. of exercises for developing specific muscles	Series no./ repetition no. for each exercise
Monday, Thursday	1. shoulders: 3 (dumbbells lateral raise, front raise and push press)	4/10-15
	2. chest: 1(push-ups)	4/10-15
	3. legs: 3 (squat, forward and side-step lunge)	4/10-15
Tuesday, Friday	1. abdomen: 3 (leg raises, sit-ups, raising both upper body and legs)	4/10-15
	2. back: 3 (prone back extensions, raising only the legs, only the upper body, and both)	4/10-15
Wednesday, Saturday, Sunday	rest	

Statistical analysis

All data obtained in this study were analyzed using the statistical programs STATISTICA 7 and SPSS 12. Descriptive statistics parameters were calculated for all of the variables (Malacko & Popović, 2001). For assessing the effects of the applied experimental program, the MANCOVA and ANCOVA covariant analyses were applied Malacko et al. (2001).

RESULTS

Table 5 Descriptive statistics for all the groups at the initial testing

Variables	E1			C1			E2			C2		
	AM	SD	KS(p)	AM	SD	KS(p)	AM	SD	KS(p)	AM	SD	KS(p)
StaT10C	5.88	0.91	0.99	6.32	0.79	0.99	5.36	0.39	0.63	6.09	0.683	0.97
StaT10B	6.30	0.83	0.84	6.93	1.46	0.94	6.05	0.82	0.77	7.01	1.083.0	0.87
SwT10C	8.21	1.35	0.89	7.99	1.21	0.72	9.22	0.96	0.67	8.08	1.297.0	0.49
SwT10B	9.98	1.26	0.66	10.53	1.56	0.76	9.96	0.89	0.88	9.71	0.883	0.30
TTC	8.06	1.09	0.71	8.34	1.02	0.44	8.27	0.98	0.99	8.28	1.198.0	0.99
TTB	9.91	1.63	0.89	9.94	1.40	0.92	9.90	1.42	0.83	9.96	1.052.0	0.93
SLC	92.07	2.76	0.87	94.10	2.02	0.47	93.41	0.95	0.94	93.23	1.474.0	0.98
SLB	91.76	2.11	0.91	92.43	3.24	0.29	90.03	4.85	1.00	90.43	2.733.0	0.98
SEC	63.71	12.62	0.85	52.93	13.85	0.50	71.87	17.26	0.98	72.42	8.371.0	0.34
SEB	49.39	8.29	0.72	40.44	9.37	0.76	56.30	14.09	0.99	56.56	7.597.0	0.87
SNC	56.21	9.45	0.92	63.31	11.32	0.60	60.09	7.71	0.20	60.06	9.950.0	0.86
SNB	67.07	7.90	0.94	71.00	12.62	0.59	63.45	17.20	0.70	63.37	7.274.0	0.88
StaLC	7.48	0.96	0.96	6.57	1.29	0.32	8.85	0.98	0.96	7.98	1.033.0	0.67
StaLB	7.86	1.43	0.87	7.85	1.24	0.96	9.00	1.20	0.64	9.00	0.972	0.85
TLC	425.63	122.61	0.29	355.37	91.53	0.66	381.72	30.69	0.89	385.89	47.701.0	0.87
TLB	537.66	123.84	0.54	497.68	170.70	0.90	563.35	186.01	0.96	581.16	124.990.0	0.99

Legend: E1 – first experimental group, C1 – first control group, E2 – second experimental group, C2 – second control group, arithmetic mean (AM); standard deviation (SD), minimal result (Min); maximal result (Max); the Kolmogorov-Smirnov test significance (KS(p)).

The significance of the results of the Kolmogorov-Smirnov test presented in Tables 5 and 6 indicates that it is greater than 0.05 for all the variables tested. This in turn indicates a normal results distribution, that is, that there is no statistically significant deviation of the results and they can thus be used in further analyses.

Table 6 Descriptive statistics for all the groups at the final testing

	E1			C1			E2			C2		
Variables	AM	SD	KS(p)	AM	SD	KS(p)	AM	SD	KS(p)	AM	SD	KS(p)
StaT10C	5.32	0.86	0.99	5.78	0.98	0.96	4.87	0.47	0.86	5.66	0.85	0.64
StaT10B	5.49	0.96	0.83	6.38	1.23	0.97	4.98	0.66	0.99	6.58	1.15	0.94
SwT10C	7.24	1.07	0.68	7.53	1.10	0.25	7.22	0.99	0.86	7.40	0.87	0.36
SwT10B	8.75	1.25	0.28	10.16	1.30	0.40	8.93	1.10	0.79	8.62	0.93	0.60
TTC	7.76	0.98	0.23	7.68	0.89	0.99	7.05	0.87	0.99	7.39	0.87	0.95
TTB	9.05	1.18	0.60	9.34	1.24	0.93	8.60	1.21	1.00	9.19	0.81	0.88
SLC	91.68	2.84	0.59	93.99	1.79	0.80	92.42	1.80	0.89	92.50	1.50	0.89
SLB	90.55	3.54	0.41	91.88	3.37	0.57	89.66	3.80	0.87	89.97	2.58	0.65
SEC	70.41	13.20	0.74	58.47	14.99	0.97	83.94	21.85	0.91	76.60	11.39	0.41
SEB	53.97	9.70	0.94	44.20	10.78	0.95	62.99	14.62	0.83	62.46	11.42	0.78
SNC	54.35	8.72	0.98	61.42	10.74	0.83	52.81	6.40	0.68	55.43	8.78	0.30
SNB	65.71	10.46	0.97	69.36	10.88	0.80	62.63	13.14	0.77	61.75	7.38	0.97
StaLC	7.71	0.85	0.84	6.86	1.23	0.49	9.15	0.94	0.77	8.23	1.06	0.88
StaLB	8.73	1.20	0.97	8.13	1.46	0.97	9.75	1.22	0.39	9.11	0.85	0.98
TLC	429.94	111.71	0.29	350.62	71.99	0.55	394.66	50.57	0.25	396.71	45.74	0.96
TLB	585.93	143.48	0.37	526.77	172.68	0.86	598.95	164.42	0.92	597.48	131.09	0.98

Legend: E1 – first experimental group, C1 – first control group, E2 – second experimental group, C2 – second control group, arithmetic mean (AM); standard deviation (SD), minimal result (Min); maximal result (Max); the Kolmogorov-Smirnov test significance (KS(p)).

Table 7 shows the significance of the differences between the arithmetic mean values for all freestyle-technique motor ability variables at the final testing, controlling for differences at the initial testing between the experimental and control groups. Based on the results of Wilks' lambda (0.460) and the F-test (2.344), it was determined that there was no statistically significant difference between the participants in the first experimental group and those in the first control group in terms of the motor ability specific to the freestyle technique (0,070). Consequently, it can be concluded that the applied training program which included a dry-land component did not lead to a statistically significant improvement of the motor ability specific to freestyle among swimmers aged 10-12.

Table 7 The multivariate analysis of covariance motor abilities specific for the freestyle, for the first experimental and control groups

Wilks' lambda	F	df1	df2	Sig.	Partial Eta Squared
0,460	2,344	1	31	0,070	0,540

Table 8 shows the significance of the differences in the values of the arithmetic means for all the breaststroke-technique specific motor ability variables at the final testing, controlling for the differences at the initial testing between the first experimental and control groups. Based on the values of Wilks' lambda (0.321) and the F-test (4.225), the difference between the participants in the first experimental group and those in the first control group was found to be statistically significant in terms of motor ability specific to breaststroke (.007). In this case, 68% of the variation was explained.

Table 8 The multivariate analysis of the covariance in the field of motor abilities specific to breaststroke, for the first experimental and control groups

Wilks' lambda	F	df1	df2	Sig.	Partial Eta Squared
0,321	4,225	1	31	0,007	0,679

An individual analysis (Table 9) identified statistically significant differences in the following variables: start time for the 10m breaststroke (0,001), swimming velocity for the 10m breaststroke (0,028), breaststroke stroke length (0,024) and breaststroke turn length (0,039). We conclude that the experimental treatment produced statistically significant effects in terms of start speed and absolute swimming velocity, which is confirmed by the results obtained for the variables start time for the 10m breaststroke and swimming velocity for the 10m breaststroke. Moreover, the experimental group scored better for turn length. The only variable with statistically significantly lower scores compared to the control group was stroke length. The other scores were not statistically significant, but were predominantly in favor of the experimental group. Consequently, the applied program can be said to be efficient in terms of improving the results for motor ability specific to the breaststroke in swimmers aged 10-12.

Table 9 The univariate analysis of covariance in the field of breaststroke-specific motor ability variables, first experimental and control groups

Variables	Group	Adj.Mean	Mean Difference (E1-C1)	F	Sig.
StaT10B	E1	5,566	-0,765	14,220	0,001
	C1	6,361			
SwT10B	E1	9,081	-0,846	5,473	**0,028**
	C1	9,927			
TTB	E1	9,062	-0,275	1,376	0,253
	C1	9,337			
SLB	E1	90,561	-1,320	5,824	0,024
	C1	91,880			
SEB	E1	49,191	1,458	,818	0,375
	C1	47,733			
SNB	E1	67,339	-0,833	,237	0,631
	C1	68,171			
StaLB	E1	8,615	0,391	,851	0,366
	C1	8,224			
TLB	E1	579,476	47,936	4,810	**,039**
	C1	531,540			

Table 10 shows the significance of differences between the second experimental and control groups in the arithmetic mean levels at the final testing for all the variables pertaining to the freestyle-specific motor ability, controlling for differences at the initial testing. Based on the values of Wilks' lambda (0,218) and the F-test (4,473), it was ascertained that there was a statistically significant difference between the participants in the second experimental group and those in the second control group in terms of freestyle-specific motor ability (0,015). In this case, 78% of the variance was explained.

Table 10 The multivariate analysis of covariance in the field of motor abilities specific for the freestyle technique, second experimental and control groups

Wilks' lambda	F	df1	df2	Sig.	Partial Eta Squared
0,218	4,473	1	25	**0,015**	0,782

Regarding individual contributions to the difference (Table 11), the only statistically significant difference, in favor of the experimental group, was identified for the variable stroke efficiency for the freestyle. Furthermore, the second experimental group had better, albeit not statistically significantly so, results for all other variables compared to the control group. This leads us to conclude that the experimental program had a positive effect on specific motor ability in the category of swimmers aged 10-12.

Table 11 The univariate analysis of covariance in the field of the motor ability specific to the freestyle technique, second experimental and control groups

Variables	Group	Adj.Mean	Mean Difference (E1-K1)	F	Sig.
StaT10C	E2	5,119	-0,383	1,932	0,182
	C2	5,503			
SwT10C	E2	7,145	-0,316	0,665	0,426
	C2	7,461			
TTC	E2	6,826	-0,728	3,866	0,066
	C2	7,554			
SLC	E2	92,078	-0,657	0,708	0,412
	C2	92,736			
SEC	E2	87,027	12,536	16,251	**0,001**
	C2	74,491			
SNC	E2	52,415	-3,300	2,490	0,133
	C2	55,715			
StaLC	E2	8,538	-0,120	0,174	0,681
	C2	8,658			
TLC	E2	400,079	13,329	0,139	0,714
	C2	388,749			

Table 12 shows the results of the differences in arithmetic mean levels for all the variables related to the motor ability specific to the breaststroke technique at the final testing, controlling for differences at the initial testing between the second experimental and control groups. Based on the values of Wilks' lambda (0.411) and the F-test (1.793), the participants in the second experimental group did not exhibit a statistically significant difference compared to the participants in the second control group in terms of the motor ability specific to the breaststroke (0.191).

Table 12 The multivariate analysis of covariance in the field of motor abilities to the breaststroke technique, second experimental and control groups

Wilks' lambda	F	df1	df2	Sig.	Partial Eta Squared
,411	1,793	1	25	,191	,589

It can be concluded that the experimental treatment did not produce any significant effects on motor ability specific for the breaststroke technique with the second experimental group, when compared against the second control group, in the category of swimmers aged 13-14.

DISCUSSION

With the first experimental group, namely swimmers aged 10-12, significant training effects were only realized for the breaststroke. Looking at the individual variables, a statistically significant improvement of the results, compared to the control group, was realized in the following variables: breaststroke start time for the 10m swim, swim time for the 10m swim, and turn length. Similarly to the present study, Pešić, Jorgić, Madić & Okičić (2013), working with approximately the same age range of 10- to 12-year-old swimmers, found that additional training on dry land led to statistically significant improvements across all tested parameters for specific motor ability, including start time for the 10m and swim time for the 10m breaststroke. Unlike the present study, however, Okičić, Madić, Aleksandrović, Thanopoulos, Bojić & Jorgić (2010) found positive effects for the crawl technique, in the form of enhanced stroke length, stroke power, and stroke tempo in swimmers aged 10-12 years. The experimental treatment in their study lasted 6 months, which may be one of the reasons for the better effects of the applied exercise program. In the second experimental group, i.e. swimmers aged 13-14, statistically significant effects were only observed in the freestyle technique, more specifically in the variable stroke efficiency. Potdevin, Alberty, Chevutschi, Pelayo & Sidney (2011) reported positive effects of an additional 6-week plyometric training on the enhancement of specific motor abilities related to starting and turning for the freestyle in female swimmers aged 14. In view of the results obtained in their study, applying plyometric training for swimmers can be recommended for improving specific motor abilities, namely those elements of the race where the explosive strength of the legs, as in starting and turning, is crucial. The study by Girold, Jalab, Bernard, Carette, Kemoun & Dugue (2012) also confirms the positive effects of additional dry-land strength training for the freestyle. Here, additional strength training was applied to 24 swimmers divided into three groups, followed by electric stimulation, where the third group was the control one. After a 4-week experimental training process, an improvement was observed for the first group in terms of swimming speed for the 50m crawl, as well as for stroke length. The authors conclude that strength training was much more effective for improving swimming performance compared to training done entirely in water. Based on the results reported in these studies, a combination of exercise programs in water and on dry land would appear to produce incomparably more significant quantitative changes in specific motor abilities, compared to training realized in water alone. However, in contrast with these studies, there are also those which have found no statistically significant improvement following additional strength training on dry land. Tanaka, Costill, Thomas, Fink & Widrick (1993) found no significant effects of additional strength training compared to training done only in water. The study they conducted took place over 14 weeks, with the experimental group undergoing additional dry-land strength training. The results pointed to equal improvement in the specific motor abilities both in the experimental and in the control group, with no significant differences between the groups. Nuno, Marinho, Reis, Tillaar, Costa, Silva & Marques (2010), studying swimmers in the 13- to 14-year-old group, also found no significant improvement in the swimming performance on the 25m and 50m swim in the group undergoing additional strength training compared to the group training in water alone. The experimental training program was 8 weeks long, and the additional strength training consisted of bench presses, leg extensions, jumps, and medicine-ball throws. Similarly, in the study by Trappe & Pearson (1994) no significantly better effects were found, such as the improvement of specific motor abilities following the application of additional dry-land strength training. Thus, after 12 weeks of applying the experimental program, no significant differences were observed in stroke length or tempo.

CONCLUSION

The results of studies carried out to date on the effects of additional dry-land strength training on swimmers' specific motor abilities differ in terms of the realized effects. The majority of studies find that additional strength training on dry land produced better results compared to applying swimming training in water alone. However, there are also studies which do not support such conclusions. This leaves room for the modification of existing and application of new experimental programs with the aim of achieving the best possible effects during the training process. The effects obtained in the study conducted are insufficient, seeing as there was an improvement in results only for breaststroke start speed for the 10m swim, swimming speed for the 10m swim, and turn length in swimmers aged 10-12, and for stroke effectiveness in the crawl technique for swimmers aged 13-14. In relation to this, a modification of the training program applied is recommended, in that a future study should include a progression in the strength training every four weeks, whereas in the present study the total training load was equal during all 12 weeks. Furthermore, the recommended frequency of applying strength exercises for shoulder, chest and leg muscles is four times a week, instead of twice weekly, as in the present study.

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UTICAJ DODATNOG TRENINGA SNAGE NA SPECIFIČNE MOTORIČKE SPOSOBNOSTI MLADIH PLIVAČA

Cilj ovog istraživanja bio je da se utvrde efekti treninga snage na suvom na motoričke sposobnosti mladih plivača starosti 10-14 godina. Uzorak ispitanika činilo je 60 plivača, starosti 10-12 i 13-14 godina, podeljenih u dve eksperimentalne i dve kontrolne grupe. Merni instrumenti obuhvatili su 16 varijabli kojima su procenjivane motoričke sposobnosti u okviru disciplina 100m kraul i prsno. Eksperimentalni program trajao je 12 nedelja. U poređenju sa kontrolnim grupama, eksperimentalne grupe male su dodatne treninge snage na suvom, koji su za cilj imali razvoj većih mišićnih grupa u celom telu. Nakon primene eksperimentalnog programa, statistički značajni efekti identifikovani su u pogledu napretka u okviru sledećih varijabli: početak na 10m prsno, dužina zaveslaja prsno, i dužina okreta u prsnom za plivače starosti 10-12 godina, dok je za plivače starosti 13-14 uočen napredak u varijabli efikasnosti zaveslaja u discipline kraul. Na osnovu sveukupne analize, zaključili smo da bi eksperimentalni program zahtevao modifikaciju u pogledu daljeg treninga sa ciljem da se postignu još veći efekti treninga koji bi dalje doveli do značajnijih transformacija rezultata plivanja u kategorijama plivača starosti 10-12 i 13-14 godina.

Ključne reči: *trening na suvom, motoričke sposobnosti, rezultati u plivanju*